A Survey of Interactive Electronic Technical Manuals Used for Training and Education

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13. ABSTRACT (Maximum 200 words)
The Navy Personnel Research and Development Center (NPRDC), working with the Naval Sea Systems Command (NAVSEA) and Chief of Naval Education and Training (CNET), completed a program of research, development, and evaluation for automating classroom activities in which interactive electronic technical manuals (IETMs) are used. The project addressed two Navy training problems: (1) the need to utilize emerging technologies to improve maintenance performance and reduce maintenance costs and (2) the need to improve the efficiency of the Navy training pipeline. These problems are being addressed by combining IETM technology with an integrated electronic multimedia editing and delivery system.

The survey and analysis was conducted of practices in the design, development, and application of education and training that incorporates interactive, hypermedia-based and IETM-like documents. An overview of IETMs is provided. Applications surveyed included such instructional settings as traditional classroom instruction, virtual classrooms, and on-demand and just-in-time instruction. The survey also covered both Navy and non-Navy applications. Non-Navy activities included other military, government, industry, and higher education organizations.

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Foreword

The Interactive Electronic Technical Manual/Automated Classroom (IETM/AC) Technology project was sponsored by the Bureau of Naval Personnel under Program Element 0603707N. This survey of IETMs used for training and education was completed under the Navy Personnel Research and Development Center Contract N66001-91-D-9502.

The survey and analysis was conducted of practices in the design, development, and application of education and training that incorporates interactive, hypermedia-based and IETM-like documents. This report is directed to training communities and program managers who may be developing or implementing IETMs.

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Summary

Background

Navy Personnel Research and Development Center (NPRDC), working with the Naval Sea Systems Command (NAVSEA) and Chief of Naval Education and Training (CNET), completed a program of research, development, and evaluation for automating classroom activities in which interactive electronic technical manuals (IETMs) are used. Advances in technology based on electronic data conversion, storage, transfer and standards have provided the Navy with the opportunity to investigate the design and development of prototype automated classrooms. This new learning environment may provide significant advances in instructional development and presentation effectiveness, as well as efficiencies in costs.

Objective

The objective of this survey and analysis was to identify lessons that have been learned, problems and issues that have been identified, and successful techniques and tools that have been developed. The goal was to report these findings and thereby enhance future integration of IETM technology and training.

Approach

The topic of IETMs and their integration into education and training is relatively broad and can be technically complex. It is expected that the readers of this report will be a diverse group with a broad spectrum of backgrounds. Therefore, an overview of IETMs is provided. Applications surveyed included such instructional settings as traditional classroom instruction, virtual classrooms, and on-demand and just-in-time instruction. The survey covered both Navy and non-Navy applications. Non-Navy activities included other military, government, industry, and higher education organizations.

Conclusions

IETMs impact not only how people access, navigate, and use technical documents but also impact the job definition, aspects of training, and the organizations responsible for job functions, training, and technical documents. The integration of IETM technology into training and education requires a look at the roles and functions of organizations.

The introduction of computers in classrooms and laboratories to support instruction using IETMs parallels the movement to implement electronic classrooms. The current model of the classroom being instructor-led with group-paced instruction is now being transferred to the IETM-based electronic classrooms. The classroom will continue to change as its functionality is enhanced by new technology.

IETM-based training may result in fewer courses and less training time. An option being considered is to move advanced training out of the classroom and into the field with smart IETMs and computer-based training that can be accessed as needed. For example, the concept of just-in-

time training with a performance support system may be appropriate for areas such as aircraft maintenance.

IETM technology may redefine jobs and training requirements. Several organizations expressed strong preferences for the capability to support the technician through more use of IETMs as expert job aids and less use of training. The more intelligence built into an IETM, the more support for equipment operators and maintainers.

Given the cost of data development for both technical manuals and training, and the commonality of information used in both applications, it seems reasonable to consider integrating the databases to support diverse applications.

Educational organizations were found to be very active in producing and using hypertext/ hypermedia documents. Often the goal is to teach students how to access information, determine relationships, use information to solve problems, and develop multiple perspectives on the information. IETM technologies can be used to support such goals in education.

Contents

List of Tables

Section One

Introduction

1.0 Introduction

The Navy Personnel Research and Development Center (NPRDC), working with the Naval Sea Systems Command (NAVSEA) and the Chief of Naval Education and Training (CNET), is currently conducting a program of research, development, and evaluation for automating classroom activities in which electronic technical manuals are used. Advances in technology based on electronic data conversion, storage, transfer and standards have provided the Navy with the opportunity to investigate the design and development of prototype instructor and student stations that may provide not only significant advances in instructional development and presentation effectiveness, but efficiencies in costs. The advanced hardware and software technologies which have emerged to make this possible include: (1) high quality digital multimedia, (2) hypertext/ hypermedia to allow greater use of information in all forms, (3) the capability to store digital media materials with greater flexibility and less costs through storage technology such as CD-ROM, and (4) transmission of multimedia through local, wide area, and worldwide networks.

Navy logistics and documentation agencies also have noted the advancing technologies and applied these capabilities to support Navy operators and maintenance technicians. A primary effort has been focused on the design and development of Interactive Electronic Technical Manuals (IETMs). IETMs are intended to solve a number of problems including: (1) the information intensive job support required by today's complex equipment and systems, (2) the paper intensive representation of that information (with associated problems of storage and retrieval both ashore and afloat), and (3) the access to relevant information in a timely, on-demand manner. IETMs, as intelligent electronic documents, are specifically designed to address these problems and thereby improve job performance while reducing costs of operation and maintenance.

For the military, there is a natural marriage of the two functions, technical documentation and training, based on the common advanced technology that can enhance both. As IETMs become more common they will be used in training classrooms and field training, and in turn they will be supplemented by training materials. There is a clear need to include documentation and training support plans early in the system acquisition process.

1.1 Purpose

A survey and analysis was conducted of practices in the design, development, and application of education and training that incorporates interactive, hypermedia-based and IETM-like documents. The purpose of the survey was to identify lessons that have been learned, problems and issues that have been identified, and successful techniques and tools that have been developed. Our goal was to report these and thereby enhance future integration of IETM technology and training. The applications surveyed included such instructional settings as traditional classroom instruction, virtual classrooms, and on-demand and just-in-time instruction. The survey included both Navy and non-Navy applications. Non-Navy activities included other military, government, industry and higher education organizations. The survey was conducted through site visits, phone calls, and reviews of documentation.

1.2   Organization of the Report

The topic of IETMs and their integration into education and training is relatively large and can be technically complex. It is expected that the readers of this report will be a diverse group including education and training specialists, computer and communication experts, career Navy personnel from a broad spectrum of backgrounds, weapon system acquisition and support personnel, and both traditional and electronic documentation authorities.

For these reasons:

- Section 2 discusses the nature of IETMs. Although the primary objective of the report is to address the integration of IETM technology and training, it is necessary to discuss aspects of IETM technology to place the implications for training in perspective. Those readers who are well acquainted with IETM technology can skip or skim Section 2. Those readers who are new to IETM technology should read it initially for a cursory understanding only. In later sections, we make specific references so readers can make the link between the IETM technology and the training implications.

- Section 3 describes current and planned applications covered in the survey of IETM practices.

- Section 4 discusses the integration of IETMs with training and education on the basis of both currently implemented or planned applications included in the survey. This section describes the many considerations, including the evolving decision and planning techniques, that need to be addressed in integrating IETMs and training.

- Section 5 describes the differences between job performance support documentation and training. This section highlights some very important differences between the two applications. We argue that although a great deal of common data is utilized, the differences in objectives are fundamental to how respective electronic documents in these applications are designed, presented, maintained, managed, and used.

- Section 6 summarizes the lessons learned, issues and problems, and successful trends. The conclusions recommend some points of integration for the future.

- Section 7 presents the references to other documents included in this report.

1.3   Evolutions

The evolutionary nature of IETM technology, goals, and developmental aspects are evident throughout this report. Likewise, the integration of IETMs with education and training is also evolutionary and discussed as such. It is important to recognize the evolutionary nature of these applications of technology as well as the evolutionary nature of the technologies themselves. Not to see the evolutions in perspective could mean missing the larger picture of where we are headed in the logistics, documentation, and training communities and how we should plan for a reasonably solid infrastructure upon which to complete our respective taskings. This is a matter of importance not only to Navy operational management, but to system commands, research and development laboratories, and education and training commands.

Section Two

Nature of Interactive Electronic Technical Manuals

2.0   Nature of Interactive Electronic Technical Manuals

The technologies of computers, communications, digital multimedia and distribution media have provided new capabilities for publishing and distributing electronic documents. We now have electronic magazines, newspapers, newsletters, how-to-do-it manuals, professional conference proceedings, and other documents available through such sources as CD-ROM and the Internet. Both the technologies and the tools for using them are rapidly increasing in functionality and accessibility. This, in turn, continues to expand the types and numbers of applications that are developed as well as changing the way we perform many daily activities at work, leisure and home.

We will discuss one particular class of such documents--Interactive Electronic Technical Manuals (IETMs)--that are used as support for job performance in the military. In particular, these manuals have been designed to increase the effectiveness of technicians who maintain equipment by supporting activities such as troubleshooting, fault diagnosis and isolation, and repairs. We intend to illustrate the impact of such documents on not only how people access, navigate, and use job documentation but also on how they can impact the job definition, all aspects of training, and even the organization(s) that are responsible for the job functions, training and documents themselves. In the conclusions in Section 6 we argue that the impact is such that an evolution is under way and integration of training and technical information technologies is required.

2.1   Overview of IETMs

To discuss the impact of IETMs on training it is necessary to briefly describe what they are and why they came to be. IETMs have several defining characteristics and this causes some differences among definitions given by various sources. We will attempt to incorporate the important characteristics in the definition provided here. On the one hand, IETMs are electronic documents with hypertext, hypermedia features. They are viewed by means of commercially available, or in some cases government owned, viewer software on a computer screen and can be used to access technical information needed to troubleshoot and help in the repair of equipment.

On the other hand, IETMs are technical information databases--consisting of text, graphics, tables, and potentially other objects of data--that also include files that define the documents structure and content to be viewed. These latter files identify Standard Generalized Markup Language (SGML) tag meanings related to the objects of the data base. SGML is a metalanguage (based on an international standard ISO 8879), which is extensible itself, whose purpose is to provide rules for managing, distributing, and publishing documents. SGML is used to define the structure and content of a document but not its appearance or presentation. The viewing software does the latter. The result of all of the information in the database is that it is possible to have a highly interactive electronic document that, as we will discuss later, can have the expertise built in to either solve equipment maintenance problems or interact to help the technician to solve them more quickly than with a linear, paper manual. The technician may follow built-in logic to identify equipment symptoms, possible problem(s), and related solution(s).

An IETM, then, is an electronic document that is assembled for viewing from a database of technical information and can interact with a technician to expertly maintain equipment. In actual practice, there is wide variation on how IETMs look and feel, the interactivity that is built in, and

the way expertise is used to guide the technician. This has resulted in classes of IETMs being defined formally as a way to describe individual efforts. Discussion of those classes and their meaning will be covered shortly. Regardless of the class, it should be recognized that the data base functionality inherent in an IETM will potentially impact training.

2.2   Need For IETMs

It was not only the promise of technology that caused many people in the military to investigate the possibilities of electronic information technology for replacement of paper technical manuals. The problems that are inherent in the paper documentation system itself-- including the life cycle of preparation, maintenance, updating, applicability to the intended using population, and logistical support for access--prompted the initiatives toward electronic documents (Rainey, Fuller, & Jorgensen,1989; Link, Von Holle, & Mason, 1987). One reason for the problems is that the shear volume of manuals required to operate and maintain the equipment of today is immense and growing with the increasing sophistication of the systems. This causes problems in confined spaces such as on tanks and ships. The AEGIS cruiser, for example, is said to require 65 tons of paper manuals. In addition, there were often complaints that the paper manuals were incomplete, inaccurate, out of date, poorly organized and difficult to use. Other factors contributing to the problems were related to the users of the manuals. There were discrepancies between the different reading levels of the people using the paper manuals and the single reading level to which the manuals were written. In addition, drops in reenlistment rates can mean continued use of the technical information by less experienced workers.

One might say that with all of those problems why not fix the paper technical manual system. Attempts were made to do just that. However, part of the problem is the volume of the paper needed to document the information required. It is not the people, techniques or organizations that are at fault. The volume of paper and the logistics of its development and support were often unmanageable. New efforts to develop paper job aids which were more complete and better organized for differing levels of users simply resulted in much bigger volumes of paper (Thomas & Clay, 1988). At the same time, there has been a serious inflation of costs for paper documents accompanied by a decrease in budgets to do everything necessary, including documentation.

To judge the viability of computer-based electronic documents as an alternative, several organizations in the military conducted feasibility, proof of concept, and demonstration efforts. Although each effort was done with a limited set of technical information on a small scale of participation and time, the results were unequivocally positive. For example, one study (Nugent, Sander, Johnson, & Smillie, 1987) compared technician troubleshooting effectiveness between a paper manual and a computer-based document that included expert troubleshooting procedures and guidance through diagnostic events. The results indicated that maintenance technicians using the computer-based, electronic document as a job aid completed troubleshooting tasks in less than half the time it took those with paper manuals. Furthermore, the technicians using the electronic aid tested an average of 65% more test points in that reduced time. Even novices using the electronic document aid could troubleshoot 12% faster than experienced technicians using a paper manual (novices using a paper manual took 15% longer than the experts). Additional studies addressed maintenance effectiveness with other equipments, types of technicians, and varieties of electronic

manuals. Indications of high user acceptance and greater ease in revisability of the documents were also identified in such studies (Rainey, Fuller, & Jorgensen, 1989).

A shift in the thinking about the role of IETMs as job aids rather than simply electronic versions of paper manuals began to surface. The small scale demonstrations and studies usually included such techniques as coaching or other guidance for use of the technical information and even expert troubleshooting paradigms to help solve problems. All of these studies led to wider recognition of the gains that could be obtained with electronic documents, used as job aids, for maintenance of equipment. As part of this same evolution the services formed joint working groups to determine common concerns and solutions. Through Department of Defense Tri-Service efforts, standard specifications for military wide development and application of IETMs came about (MIL-M-87268, 1992; MIL-D-87269, 1992; MIL-Q-87270, 1992). There are a large number of IETM developments underway. Some are entering completion stages and will soon be available for use on the job. Some are available now. A few are being used in formal training programs and many more will soon be entering that arena.

2.3   IETM Technology

ETMs are possible because of technological advances over the past few years in several areas. Some of the same technology that underlies IETMs can also provide the technological basis for integrating IETMs and training. Therefore, it is of value to briefly discuss some relevant aspects of IETM technology. Recently, a briefing by personnel from the Air Force Armstrong Laboratory (Masquelier, 1995) described the technological advancement for the Air Force Integrated Maintenance Information System (IMIS) across three phases of development. These are:

- Phase I: Electronic Manuals (1982-1987).

- Phase II: Interactive Diagnostics (1986-1992).

- Phase III: Integrated Information (1988-1993).

An early report on the state of automated technical information, such as IETMs, by researchers at the Navy's David Taylor Research Center (Rainey et al., 1989) described the following advances:

- Advent of automated work stations for creating and merging text and graphics.

- Greater information storage density and retrieval access.

- Increased capability of small computers.

- Development of low-cost, high resolution laser printers.

- Improvement in software for information scanning.

- Improved display systems technology.

- Better database management system software and technology.

- Extensive improvement in computer-aided design and engineering.

- Advances in networking technology.

However, of all of the technological advances underlying the interactive electronic document the most dramatic may be the advent of SGML. Much of the early work in the military on electronic technical manuals took place without the power of SGML. It was not until 1986 that the ISO standards for SGML were published (ISO/IEC 8879). Charles Goldfarb, a lawyer who worked for IBM, invented a way for lawyers to research a subject from large text bases, edit and add to it, and thereby publish a document for legal use. He developed SGML to fill a void in the word processing, publishing and retrieval systems that were available. None of them, even in combination, could do what was needed and if they came close they could not talk to each other because of proprietary file formats and inconsistent treatment of text and graphics structures. Goldfarb (Hanlon, 1995a) realized that traditional publishing uses formatting to convey structure to the reader. For example, to indicate a new chapter a break occurs in pagination and a title is prominently displayed at the top of the page. Goldfarb developed a tool for describing the underlying structure of the document (headings, abstracts, sections, etc.) regardless of the formatting style to be used.

SGML fulfills a goal to produce a single set of rules for describing the structure and managing the content of a digital document. It is an open standard and a shared technology so it is not owned by anyone and is available to all. It is also free from hardware and software proprietary considerations and, in theory, the changes in hardware and software technology. A major reason often touted for incorporation into CALS (Commerce at Light Speed, formerly called Continuous Acquisition and Life Cycle Support) conventions is that SGML allows the data to outlive the life of hardware and software available. The SGML rules, in the form of a metalanguage, provide a way to extend SGML features and we can expect it to evolve with experience. The Hypertext Markup Language (HTML), used to define material on the World Wide Web, is an example of how experience will change SGML. HTML is a specific subset of SGML rules used to define WWW document types. HTML has gone through several versions, some of which bend current SGML rules, that have been enhanced to meet project needs. Eventually SGML may be extended officially to meet WWW type documents.

Beyond these advantages, SGML provides a new paradigm for working with digital information. A key aspect of the paradigm is that SGML is not concerned with the appearance or presentation of a document. An SGML document is an information container, not the screen or hard copy output. A document may be thought to consist of three layers: structure, content, and style (Arbortext, 1995). SGML separates these three layers and provides ways to directly define the relationship between structure and content. To do this an SGML document can be thought to have three parts which, taken together, define for a given type of document its structure, the content of the document, and the relationship of structure and content. First, there must be a declaration; a text file that contains system specific information such as character sets. Second, there must be a declaration of the document type and incorporation of the Document Type Definitions (DTD) that are to be used. The DTD is a set of rules stated in SGML to define the structure of a document and a list of all of the permissible elements and entities that can be included in the document. Elements and entities are the units of digital information that are to be included in the document. Third, the document instance consists of the actual text with markups called SGML tags that are defined in

the DTD. The document instance is, therefore, directly related to the DTD. There are no non-text objects in the instance file. All Graphics, for example, are external to the instance and referred to as external entities.

The SGML tags, defined in the DTD and incorporated in the document instance to define the relationship between structure and content, are the equivalent of penciled markups that are often used on the printed page when we want to identify characteristics of the document such as bolding, position on the page, or heading and paragraph types. However, the SGML markups do much more. When a tag is used to identify a document element such as a unit of text information it can also have attributes that add intelligence to the document, improve navigation, and trigger actions to be taken automatically. This increases the user productivity by decreasing time to access information and providing a smart interface between the user and the document.

2.4   IETM Classification System

Over the past few years, as the IETM specifications and standards were drafted and promulgated, it became necessary to consider that not all IETMs can be created equal. For example, there will be differences related to whether there is a large amount of legacy documentation, perhaps in hard copy form only, versus a new weapon system acquisition that can allow authoring directly for screen interaction in logical information chunks versus whole linear page displays. There will most certainly be differences in budgets and time that will effect how much can be done to provide intelligent documents which are easy and functionally efficient to use.

Given that there are and will be differences, the groups working on IETMs drafted definitions of classes of electronic technical manuals. This too has been, appropriately, an evolutionary process. The definitions have changed and probably can be expected to continue to change. At one time, in fact, the Navy had one classification system and the Army and Air Force at least one other (Alligood, 1994) More recently, the IETM Tri-Service Working Group has accepted the definitions shown in Table 1. This information (dated September 2, 1994) was taken from the World Wide Web home page of the Naval Surface Warfare Center, Carderock Division (http://navysgml.dt.navy.mil/classes.html). This latest set of definitions differs in several important ways from a previous definition of classes (dated January 24, 1994). We will briefly discuss the differences and characterize the current definitions in terms of their relevance to training. The characteristics of the classes and the differences among the classes are important to the integration of IETMs and training in several ways that will be expanded on later.

Table 1

Tri-Service Definitions for Classes of Electronic Technical Manuals

	Class 1 Electronically Indexed Pages	Class 2 Electronically Scrolling Documents	Class 3 Linearly Structured IETMs	Class 4 Hierarchically Structured IETMs	Class 5 Integrated Data Base
Display	• Full page viewing • Page turner/next function • Intelligent index for user access to page images • Page integrity preserved	• Primary view is scrolling window • Hot-spot access (Hyper-links) to other text or graphics • User selection and navigation aids (key word search, on-line indices) • Minimal text-formatting for display	• View smaller logical block of text with less use of scrolling. • Interaction through dialog boxes • Interaction per MIL-M-87268 to extent possible • Text and graphic simultaneously displayed in separate window when keyed together	• View smaller logical block of text with very limited use of scrolling • Interaction through dialog boxes with user prompts • Interaction per MIL-M-87268 to extent possible • Text and graphic simultaneously displayed in separate window when keyed together	• Same as Class 4 for IETM function • Interactive electronic display per MIL-M-87268 • Expert system allows same display session and view system to provide simultaneous access to many differing functions (e.g., supply, training, troubleshooting)
Data Format	• Bitmap (raster) • Indexing and header files (Navy MIL-STD-29532) • MIL-R-28001 or postscript pages • Generic COTS imaging formats	• Text-ASCII • Graphics: whatever viewer supports, e.g., BMP or CALS • Can be SGML tagged-no page breaks (browser) • Access/index often COTS dependent with Hypertext browser	• Linear ASCII with SGML tags • SGML with content vice format tags • Maximum use of MIL-D-87269 • Generic SGML tags equivalent to MIL-D-87269	• Fully attributed data base elements per MIL-D-87269 • MIL-D-87269 content tags with full conformance to Generic Level Object Outlines (architectural forms) • Authored directly to database for interactive electronic output • Data managed by a DBMS • Interactive features authored in vice added-on • Generic: COTS equal to MIL-D-87269 data definition and tags	• IETM information integrated at the data level with other application information • Does not use separate databases for other application data • Identical to Class 4 standards for IETM applications data per MIL-D-87269 • Coding for expert systems and AI modules when used • Generic: COTS equal to MIL-D-87269 data definition and tags
Function-ality	• Access pages by intelligent index/ header info • View page with pan, zoom, etc., tools • Limited use of hot spots • Useful for library or reference use	• Browse through scrolling info • User selection of graphics or hot-spot reference to more text • Hot-spot and cross-reference usually added after original authoring	• Dialog-driven interaction • Logical display of data in accordance with content • Logical NEXT and BACK functions • User-selectable cross-references and indices • Content specific help available	• Dialog-driven interaction • Logical display of data in accordance with content • Logical NEXT and BACK functions • Useful as interactive maintenance aid • User-selectable cross-references and indices • Content specific help available	• Single viewing system for simultaneous access to multiple information sources • Same as Class 4 for IETM functions • Expert system to assist in NEXT functions based on info gathered in session

12

As seen in Table 1, there are three categories of characteristics used to define IETMs--Display, Data Format, and Functionality. The earlier version also had three categories--Display, Data Format, and Preparation. There was no specific reference to functionality, although such items were included to some extent under Data Format. However, many of the items currently under the Functionality category in Table 1 did not appear anywhere in the earlier version. These differences, along the dimension of functionality from the view point of the end user are, in fact, often what distinguishes one class from another. One aspect of functionality is how the end user will access, navigate, and interact with the IETM on-line. For example, we can see increasingly greater use of hypertext and hypermedia from classes 1 through 3 (references to hot spots) and the addition of dialog driven interactions beginning in class 3. Another aspect of functionality is how much intelligence and expertise the system will have that aids the performance of the user. For example, classes 3-5 provide logical next and back functions for navigation and class 5 is partly defined by an expert system that can aid in implementing next navigation by taking into account the session data such as troubleshooting results. These functionality characteristics potentially have profound impacts on job definition and training requirements because they may very well have major impacts on what the technician has to know and be able to do. The IETMs have taken on dimensions of electronic performance support systems. The importance of these characteristics and the implications for training will be further discussed in Section 4.

The Data Format category of IETM characteristics is of interest not only for defining classes but for its training development implications. A review across the five classes along this dimension reveals that the data bases change in various ways, becoming increasingly more useful and integrated for functionality. Class 1, because it starts out as a legacy hard copy manual, is a raster scanned, page turning, electronic technical manual with only an intelligent index for additional user access. It has only a bitmap database with indexing and header file data. Beginning with class 2, the text data is all digital with increasingly more useful and effective data structures, use of SGML tagging to hierarchically structure the text data and associate it to other media, and integration with other application data both at the database and user level. This integration with other data is an important principle that we will discuss in Section 4. In particular we will argue that common definitions of data items from logistics, technical information and training are necessary for integration of IETMs with training. Further, it is likely that a common database of such elements can serve the goal of efficiently training and supporting the performance of technicians and operators even better.

As a final note, it should be said that many of the IETMs we have seen or discussed with developers do not readily fit into one category or another. It is common for them to have some aspects from one class level and some from another. These multiclass IETMs are not faulty in any way. Rather, it is the nature of IETM designs, needs, budgets and developmental tools that seem to dictate their characteristics. Given the pressure to state that our IETM is a class X, we expect to see the definitions of classifications continue to evolve and become more useful to define IETMs by design, interface and functionality related to the user.

There seems to be universal agreement that classes 4 and 5 are much more expensive to develop than class 3. As reported by Hanlon (1995a), classes 4 and 5 embed much more intelligence into the database (e.g. hyperlinks, rendition information, context-sensitive filtering). Hanlon reported that 93% of the F-16 IETM developed by Lockheed was mark-up as opposed to

the actual text to be displayed on the screen. This too is of relevance to the training community because the increased job performance support that IETMs can have will probably only be seen in new, major, and complex system acquisitions with larger budgets. Training analyses, including media selection, will need to take class and category differences into account in the very near future.

2.5   IETM Development Process

Development of IETMs requires software tools and processes. Viewing the IETMs takes still different software tools called viewers or view packages. While all IETMs comply with the military standards, the process and tools for development can be considerably different. As we surveyed techniques and software used to support the authoring of IETMs, it became evident that there were several implications and issues for training that we will address later in Section 4. Specifically;

- Should training personnel be incorporated into the IETM authoring process, and if so when and how?

- Can and should training personnel incorporate IETM processes and tools for development of training materials?

The IETM development process varies from application to application. Generally speaking there are two major categories: (1) IETMs developed for existing, mature systems, and (2) IETMs freshly authored for new systems and equipment.

2.5.1   Mature System IETM Development

The following paragraphs describe two processes that have been used to develop IETMs for mature systems with legacy data in both paper and electronic formats.

Navy Gas Turbine IETMs. Alligood (1994) states that under the direction of NAVSEAs (Naval Sea System Command) Technical Data Division (SEA 04TD), the following organizations participated in the development of the Gas Turbine (GS) IETM database: (1) the prime contractor, Lockheed/Martin (formerly Martin Marietta, Ocean Systems Division), (2) the Gas Turbine Systems In-Service Engineering Activity (GS ISEA), Naval Surface Warfare Center, Carderock Division, Philadelphia Detachment (NAVSSES), and (3) New Technologies Division personnel and GS "C" school instructional staff at SSC GLAKES. The GS IETM development process followed the approach Lockheed/Martin used in developing the Navy AN/BSY-2 Combat Systems IETM. The process, as illustrated in Figure 1, takes advantage of best commercial practices for data conversion and CALS compliant tagging in SGML and best commercial practices for data translation, integration, hyperlinking, and display.

14
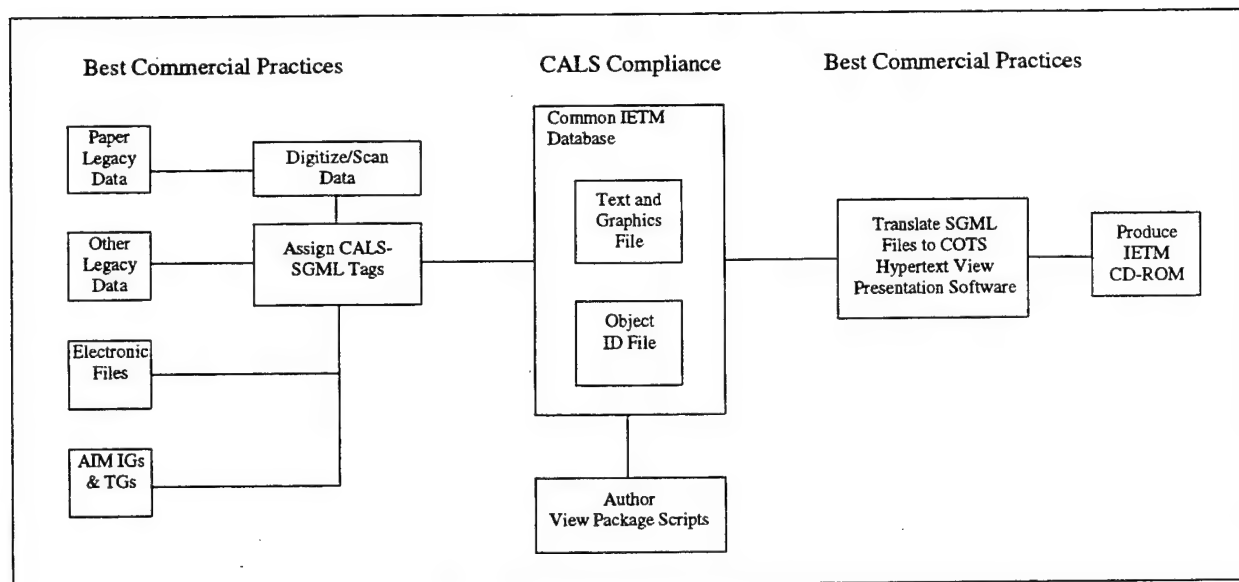
Figure 1. The gas turbine IETM development process.

Over 110,000 pages of technical information/documentation were converted and tagged during the development of the GS IETM. NAVSEA developed the Document Type Definitions (DTD). The DTD consists of a set of SGML tags (developed in compliance with MIL-M-28001B, August 1993) that were used to tag data to the paragraph level as the smallest object of data converted. Diagrams, figures, and tables were also SGML object tagged. The converted data was uploaded into an object oriented common IETM database using relational database management software. The common database consisting of two files--one file contains all of the text and graphics and the object ID file contains all of the SGML tags.

To create IETM functionality, view packages for general knowledge, troubleshooting, maintenance, and operations were developed by subject matter experts (SMEs). Each view package is a script that sets the flow from one object, such as a paragraph, graphic or table, to another that the SMEs consider the best approach to accomplish a procedure or task, such as troubleshooting a specific piece of equipment. The SMEs, consisting of personnel from SSC GLAKES (New Technologies Division and GS "C" school instructors) and NAVSSES (GS ISEA), were trained in view package authoring techniques by Lockheed/Martin staff. Development of the view packages was not difficult, but it was a labor intensive effort over a period of several months.

The view packages were authored by linking, in script format, the object file IDs (SGML tags) and applying content data model (CDM) SGML tags (defined in MIL-M-87269, November, 1992). View package scripts contained commands to link and/or launch to other applications such as video, audio, animations, and other documentation on compact disk. The scripted information was uploaded via an ASCII text editor to the common IETM database to provide positive linkage of data in native SGML format. Then Lockheed/Martin processed the database through a translator for presentation on commercial-off-the-shelf (COTS) hypertext/hyperlink software (InfoAccess

GUIDE). The IETM database was mastered on CD-ROM for dissemination to the fleet and the schoolhouse to be displayed on COTS personal computer hardware.

A Memorandum of Agreement between NAVSEA and SSC GLAKES gave NAVSEA the responsibility for developing the electronically enhanced Instructor Guides (IGs) and Trainee Guides (TGs) for inclusion in the IETM database. In addition to the view package development effort, personnel from the New Technologies division and the GSE/GSM instructional staff were also rewriting the conventional paper-based curricula for inclusion in the IETM database. Rather than revising the courses in Word Perfect and then converting them over to AIM (Authoring Instructional Materials), the Navy's current system for authoring PPP-based (Personnel Performance Profiles) instruction, the revised IGs and TGs were authored using AIM. The AIM databases were provided to Lockheed/Martin to extract and convert the training materials to SGML format for inclusion in the IETM database. The IGs and TGs have the capability to search for and launch for classroom presentation to associated multimedia such as video, audio, and graphics that are not in the IETM database.

Logistics Research and Development (LOG R&D). One early system used to convert paper documents to raster scanned digital documents was the Navy's Automated Document Conversion System (ADCS). Several of those interviewed, across the services, expressed displeasure with the use of ADCS and its final output. What is most desirable is to convert to a fully digital format that can be put into an SGML database compliant with IETM specifications. The conversion of legacy data from paper formats is an expensive process costing from $35-$200 per page, as estimated by the Naval Surface Warfare Center (NSWC), Carderock.

To eliminate or reduce those costs NSWC initiated the LOG R&D program, funded by NAVSEA, to develop functional scanning capabilities for conversion of paper based legacy manuals to digital format compliant with the IETM specifications. NSWC is looking for a more cost-effective way to re-author legacy data from paper-based traditional technical manuals. It is envisioned that alternatives for the conversion of legacy data will require the development of both recognition and decomposition techniques that can analyze and identify technical information needed to populate an IETM SGML database.

There are two aspects to the problem. One aspect is to convert text, tables, references, procedural data, warnings, cautions, and notes. The other is to convert graphics. NSWC has three contractors tasked to develop systems for demonstrations and for evaluation. Martin Marietta, Orlando, is working on an integrated system for both text and graphics. SAIC, Tucson, is working on a text conversion system. Mantech International, Fairmont, is working on a graphics conversion system. All have demonstrated initial capabilities. The next phase of the program will be complete late this year and demonstrate more complex format conversions to non-redundant databases and include projected cost data for production.

2.5.2   Authoring IETMs for New Systems

The process of authoring IETMs for new systems can use tools specifically designed to develop IETMs in classes 3, 4 and 5. Based on the results of the survey, most of these newly authored IETMs will be at class 4 or 5 levels. Since many of the software tools specifically designed for IETM authoring are under development, testing or in early stages of use, they are

subject to change as more experience is gained. Likewise, general purpose COTS authoring systems may also become more functionally related to IETM authoring as more experience is gained.

We found five IETM specific authoring systems. Four of these have some aspect owned by the government. The Army, Navy, and Air Force have all funded development of authoring capabilities as part of IETM project development. The IETM specific authoring systems, as summarized from product literature and interviews, are discussed below.

AMIDDS. The Aviation Maintenance Integrated Diagnostic Demonstration System (AMIDDS) is, like the Air Force F-16 Integrated Maintenance Information System (IMIS) concept described below, intended to provide an all encompassing and integrated support system for maintenance of Navy aircraft (Bare & White, 1995). AMIDDS is a Naval Air Systems Command R&D funded effort that includes support for pilot and aircrew debrief for fault identification, maintenance control, configuration management, parts life tracking, IETMs and 3M data collection. AMIDDS includes integration with expert system diagnostics. IETM authoring and presentation software packages have been developed for AMIDDS by McDonnell Douglas Aircraft Company. It is, therefore, government owned. The authoring system has been used to develop IETMs for the F/A-18 program at the class 5 level. These prototype IETMs, along with other prototype components of AMIDDS, are now undergoing field testing at El Toro Marine Corps Air Station. If the testing is successful the F/A 18 program will continue use of the tools resulting from the R&D.

The authoring system is an on-line, interactive, set of integrated tools that can be used by a technical writer to specifically develop IETM databases and documents at levels 4 and 5. Thus, the authoring process is specifically supported to develop and declare elements and entities such as smaller, logical, reusable text and graphics information without the writer needing to know SGML. While the output of the database is an SGML format for deliverable purposes the final database is object-oriented and relational so that integration with other such databases is feasible. The authoring software runs on work stations under an X Window operating environment. The presentation software runs on the same hardware and software environment but is also designed to run on Portable Electronic Display Devices (PEDDs) which are ruggedized and light-weight for field, flight-line usage.

AIMSS. The Advanced Integrated Maintenance Support System (AIMSS) was developed by Hughes Technical Services Company to develop and present class 4 IETMs conforming to the IETM MIL specifications. It is not clear if any of the system is government owned. Hughes offers a COTS version for sale and, according to Hughes literature, the Army has endorsed AIMSS as an acceptable COTS authoring environment. The system was originally delivered to support two Navy systems: the Advanced Large Screen Display and a digital color video generator unit (Hughes, 1995). Hughes is currently under contract to support a Navy undersea surveillance system and a digital switching system being integrated into the Canadian Air Traffic Control System. The AEGIS IETM Working Group selected AIMSS as the authoring system by for all AEGIS cruisers and destroyers.

AIMSS runs under a Windows-based environment. The authoring and run time software is integrated so it is possible to immediately see how the IETM will appear to the user. The authoring

user interface is graphical and object-based. Authors construct a hierarchical database structure by using a series of folders that represent tasks and descriptions. Complex interactive procedures are created by placing circles on the screen, interconnecting the circles and filling the circles with text and graphics. Data elements are sharable since they are defined as objects and can be used many times or combined to define new elements. A change in one object is, therefore, reflected throughout an IETM. AIMSS provides point and click hyperlinking for the author; including text, graphics, audio, video, tables and parts information objects. SGML import and export utilities are included with the authoring tool set. Hughes provides full technical and training support for AIMSS.

F-16 IMIS. The Air Force F-16 Integrated Maintenance Information System (IMIS) is a system that integrates the maintenance data and events through the entire cycle beginning with an automated pilot debrief and going through such events as pilot fault reporting, forms generation, both organizational and flight line maintenance, and post maintenance activities such as updating database records and closing out work orders (English & Keener, 1995). The F-16 IMIS includes an authoring system for IETMs. Development of the authoring system by Lockheed (Ft. Worth) began in 1989 and has been used for the early IMIS field testing by Armstrong Laboratory as well as for over 9000 maintenance tasks on the F-16 program. Tasking to Lockheed calls for the delivery of the authoring software to the CALS program. Plans for further development include merging the F-16 and F-22 authoring to a single system, adding parts data capability, providing more data management tools, and including authoring features such as audio/video support.

The authoring system is capable of producing a class 5 IETM and the F-22 IETM is a class 5 document. The rationale for making it a class 5 apparently began with an Air Force Inspector General report that criticized the capability to manage the maintenance of the F-16 program across four different versions and with foreign military sales to 16 countries. A class 5 was set as the goal, in part, to integrate all data in one data base and be able to draw from the single, manageable data base for all applications and documents. The F-16 IMIS is currently being extensively tested at several sites. However, there are no current applications in formal training programs. Although there has been discussion of incorporating features, such audio and video, that could be used by the training community, there are no immediate plans to do so.

JIMIS. The Joint STARS (Surveillance Target Attack Radar System) is also being developed based on the IMIS concept. It is being used by Grumman Aircraft for the Air Force Joint STARS program and by the Boeing-Bell Helicopter team developing the Navy V-22. The authoring system for IETMs was developed by Grumman under Government funding and therefore the Government owns the process and parts of the software. However both the authoring system and presentation mode also incorporate COTS. The authoring system for both programs incorporate the Arbortext SGML Publisher. The presentation mode can use a variety of COTS viewers. The Joint STARS IETMs will be Class 4. They will be ready in November/ December, 1995 for training aircraft differences to 5 and 7 level maintenance technicians who will support the Operational Test and Evaluation (OT&E) of the aircraft. The V-22 IETMs will also be Class 4.

IADS. The U.S. Army Interactive Authoring and Display System (IADS) has been developed as a Missile Command CALS initiative. It is Army owned and supported through the Publications Service Branch of the Integrated Material Management Center at Redstone Arsenal. IADS is compliant with IETM MIL standards and utilizes SGML to manipulate text with CALS

compliant graphics to display isometric and engineering drawings both within text and in separate windows. Both vector and raster graphics are supported (as per MIL-D-28003 CGM and MIL-R-28002 Raster Type I).

The software runs in a Microsoft Windows environment and requires a minimum configuration of an 80386 with 4 megabytes of RAM, although more complex hypertext applications need greater computer resources. There are two separate packages under IADS--one for Author and one for Reader. The Reader software is designed to display the IETM to the end user. The user has the ability to view and navigate documents to find information needed. Navigation includes menus, button commands, hot spots for hypertext links using mouse or keyboard inputs, and features such as Next, Previous, Back, and Search. Reader tools also include the capability to define private and public notes, bookmarks, reports and to print portions of the IETM or user defined text. Images displayed on the screen can be manipulated by the user also through such features as Zoom and ImageView. On-line help is provided.

The IADS Author package provides tools, with the same features that are in Reader, to create and test IETM hypertext documents with SGML tags for elements, entities and attributes. Because a flat file structure is used, the IETMs produced with IADS are inherently defined as class 3 although some other features such as display of small logical units of information are possible and there may be a mix of class 4 and 5 features that can be added. Authoring functions for file and frame properties allow fine tuning document file and frame tag attributes and a Custom Button Editor and Control Panel Editor allow adding, deleting, and modifying panel button characteristics. A style sheet package provides aids in formatting the documents on-screen appearance. IADS Author also includes a validating parser and hypertext link verifying program

The interesting aspect of IADS is that it is being used not only to author IETMs but that Army instructional staff have been trained to use it as well. Field testing of the Patriot missile IETM developed with IADS was completed at Ft. Bliss in March, 1995. The Integrated Material Management Center at Redstone Arsenal has just completed training of 105 educational specialists and instructors on the use of the IETMs and IADS. These personnel will be implementing the IETMs in the classrooms at Ft. Bliss. They will be able to develop lesson plans with links into the IETM through IADS. The lesson plans will be duplicated on student stations for student automated access to IETM material as dictated by the lesson plan. Only instructor stations will have full instructor functions for the lesson plan.

It is also possible for the lesson plans to be built, through IADS, to launch other external software such as Asymetrics Toolbook applications, which is in use now. Thus, instructors may incorporate additional materials such as graphics, animations, and other instructional aids just as they would normally but in a electronic classroom setting. Discussions with another Army office, has indicated that they are working on development of common content tagging for use by instructors. That will support instructor use of IADS to link into IETMs from the Lesson Plans developed at schoolhouses.

Current IETM and Other SGML Based Implementations

3.0 Current IETM and Other SGML Based Implementations

The survey of IETMs covered military applications across the Navy, Marine Corps, Army and Air Force. In addition, we searched for applications outside of the military that were close to the characteristics of IETMs by virtue of being electronic documents that aided the completion of a specific task or immediate acquisition of new knowledge that could be used in doing a task.

Although we initially considered looking at hypertext, hypermedia documents generally without regard to whether they were SGML based, we found that the SGML applications were much more related to IETM technology and applications. Therefore, we focused on SGML applications in reviewing projects outside of the military. The only exceptions are the research projects on instructional hypertext/hypermedia design presented in Section 5. These projects are totally centered on electronic documents and databases for learning systems as opposed to job performance support.

The applications we reviewed are organized into the following subsections. The IETM efforts in the military will be presented first. The IETM projects in other government agencies and industry will be discussed next. Finally, the applications found in higher education will be described. In each section, we will attempt to characterize the diverse efforts in order to draw out implications for the future.

3.1 Military IETMs

CALS (Continuous Acquisition and Life Cycle Support) was initiated in 1985 by DoD as a strategy for integrating logistic support processes. In 1988, DoD mandated compliance with CALS specifications. IETM specifications, considered a part of CALS, were published in late 1992. For the Navy, electronic forms of technical information and documentation have been directed by the Chief of Naval Operations in the CALS Strategic Plan (OPNAVINST 4120.5, Jan 1994). Other military branches, such as for the Army, through its Materiel Command, have also directed replacement of paper technical manuals with IETMs.

Table 2 summarizes many of the DoD IETM applications that were identified during the survey. There are undoubtedly more, but these seem to the major ones commonly known in the community.

While all of the IETMs shown in Table 2 comply with the IETM military specifications, there are substantial differences in them. For example, no two necessarily look alike. In addition, even though they all comply with SGML rules they cannot, at the SGML database level, talk to each other through the same software without some steps for conversion. There are a wide variety of IETM authoring software tools and techniques, presentation software packages, features for functionality and integration with other applications or databases, and levels of expertise built in for job performance support.

Table 2

Some Military IETMs Currently in the Field or Under Development

BRANCH AND PROGRAM	RELATED INFORMATION
Navy/Marine Corps, V-22	In Progress, Class 4 being developed with JIMIS authoring system by Bell-Boeing. Expected to be fielded for first flight of plane #7 in December, 1996
Navy/Marine Corps, APG-65 Radar System used in F-18 and AV-8B Aircraft	In preparation as a Class 5 with C++ software to integrate graphics and animation produced with COTS. Intended to have full integration of IETMs with Computer Based Training.
Navy/Marine Corps, F/A-18 AMIDD	R&D effort in Field Testing at El Toro, Class 4/5 being developed with AMIDD authoring system by McDonnell Douglas. If R&D is successful the F/A-18 program will pick up the tools developed for further application.
Navy, Gas Turbine, Electrical and Mechanical	Fielded and in School at Great Lakes. Utilizes electronic classroom technology. Developed by Martin Marietta with InfoAccess Guide Author. EBT Dynatext is viewing software. IGs and TGs are authored in WordPerfect and not integrated with the IETMs, Class 3
Navy, Mine Counter Measures	Fielded and in School at Great Lakes. Utilizes electronic classroom technology. Developed by Martin Marietta with InfoAccess Guide Author. IGs and TGs are authored in AIM and integrated with the IETMs. Class 3
Navy, Radio Communication System (RCS) for AEGIS	Class 3 fielded in 1991 and still in place. Used in training at AEGIS Training Center.
Navy, Fire Control Transmitter for AEGISS	Class 4 developed under NSWC PHD with Hughes AIMSS authoring system. Under evaluation now.
Navy, AN/BSY-2 Seawolf Class Submarines	Combat system Class 3 IETM developed with InfoAccess Guide Author. Developed by Martin Marietta. EBT Dynatext is viewing software. IETMs to be incorporated into training at Submarine School, Groton. Will be fielded in 1996. IGs and TGs are integrated and authored with the IETMs
Navy, HME & Systems for Seawolf	Hull, Mechanical, Electrical & systems level IETMs being developed at Class 2 & 3 levels primarily by Newport News & Electric Boat with InfoAccess Guide Author. EBT Dynatext is viewing software. IETMs to be incorporated into training at Submarine School, Groton.
Navy, AN/BQG-5 for Trident Submarines	Passive sonar receiving set currently fielded onboard USS Augusta SSN710 as Class 3 IETM. Developed by Martin Marietta with InfoAccess Guide Author. EBT Dynatext is viewing software. Being used in an electronic class. IGs and TGs are integrated and authored with the IETMs.
Navy, SQQ-89 for SPA 29G	Sonar system Class 3 to be developed at the Fleet Technical Support Center, Dam Neck. Not under way at time of interview.
Navy, LOG R&D	R&D program to build a functional scanner of paper legacy manuals. See the description in this report on IETM authoring of legacy data IETMs

Table 2 (Continued)

BRANCH AND PROGRAM	RELATED INFORMATION
Navy, Advanced Tomahawk	Expected in late 1996 at the Fleet Combat Training Center, Dam Neck.
Navy, MK 75/76	To be used at the Fleet Combat Training Center, Dam Neck
Navy, Close-in Weapon System	To be used at the Fleet Combat Training Center, Dam Neck
Army, Paladin Howitzer	In Progress. Aug 1997
Army, Towed Howitzer	Fielded
Army, Palletized Load System (PLS) Vehicle	Fielded and used in training at Ordnance Center & School (OC&S)
Army, Highly Mobile Multi-Wheel Vehicle (HMMWV)	In progress. May 1996
Army, Armored Personnel Carrier	In progress. December 1995
Army, M915/916 Trucks	Fielded and used in training at Ordnance Center & School (OC&S)
Army, All Source Analysis System	Fielded
Army, Armored Gun System (AGS)	In progress. 4th Qtr FY 1996.
Army, Joint Tactical Unmanned Vehicle	In progress. 4th Qtr FY 1996.
Army, Team Mate	Fielded
Army, Trail Blazer	Fielded
Army, Heavy Equipment Transporter	Fielded and used in training at Ordnance Center & School (OC&S)
Army, Explosive Ordinance Disposal	Fielded but just received at joint service school (at NSWC, Indian Head) which is reviewing how to integrate into training.
Army, Apache Longbow Attack Helicopter	In progress. 1997. Class 5 because it is being refurbished and upgraded for long life.
Army, Patriot Missile System	Fielded and now in schools at Ft. Bliss. Class 3
Army, Avenger Missile System	Fielded and now in schools at Ft. Bliss. Class 3
Army, Blackhawk Helicopter	Field Testing
Air Force, Joint STARS Aircraft	Ready for Fielding Nov/Dec 1995 as Class 4 and will be used in training then for maintenance and some mission crew operations.
Air Force, F-16 Aircraft	Class 5, in Field but not in schools
Air Force, F-22 Aircraft	In progress, Class 5
Air Force, B-2 Aircraft	In progress, Class 5
All Source Analysis System	Fielded.

As shown in the table, most of the IETMs are under development. Only ten IETMs are now in the schools. No Air Force IETMs have been incorporated into formal training to date although they will be shortly in several instances. The five Navy school IETM applications are the electrical and mechanical Gas Turbine Technician courses at Service School Command, Great Lakes, the Mine Counter Measures course (just begun this summer with IETMs) also at Great Lakes, the AN/BQG-5 sonar set course at the Trident Training Facility, and the radio control system incorporated at the AEGIS Training Center. The two of the five Army IETMs in schools are for the Patriot Missile and Avenger Missile at Ft. Bliss. The three other Army IETM based training programs are at the Ordnance Center & School. These ten applications are all reported to be in electronic classrooms, although the components in the classrooms vary considerably. (Refer to Section 4.0 for a discussion of IETMs in electronic classrooms). The five Navy school IETMs have, or will have, the Instructor and Trainee Guides for formal curricula integrated with the IETMs and distributed on the same CD-ROMs. All of the schools have integrated the IETMs into hands-on labs. The OC&S school, for example, has integrated a simulator that can be set yp as a truck with faults entered by the instructor. From the students viewpoint the contact data test set he/she is using is the real thing connected to a real truck.

Although there were some instances of using IETMs in on-demand, just-in-time training modes, these usually seemed to be impromptu and informal situations at a unit level rather than regular and planned in conjunction with training commands or other activities charged with broad-based training. The AN/BQG-5 IETM was reported to have been used for on-demand training to various groups such as shipyard installation personnel and government engineers. The integrated curriculum in that IETM was developed using an Audience Tailored Instruction development process that allows any training objective to be mapped into an on-demand training topic, course, or overview.

We found no instances of complete virtual classrooms applications such as networking IETM-based training via satellite to ships or remote sites. However, several organizations have experimented with elements of this. The Navy has experimented with use of two way audio/ video to show an instructor, using an IETM, while talking to a technician on board a ship. An Army Training and Doctrine command (TRADOC) funded initiative is now underway to begin teletraining that integrates IETMs. The Army, at the Redstone Arsenal Office of the Test, Measurement, and Diagnostic Equipment Program Manager, has a planned contract effort to study use of the World Wide Web for IETMs access for truck and tank maintenance. While these are not specifically training oriented, they are perhaps precursors to looking at the technology basis for virtual access to IETMs and training. A Web site is now in operation by the Army to support operations at the Ordnance Center & School. That Web site will be turned on for all Army access in November, 1995.

The IETMs shown in Table 2 vary considerably in terms of features. They range from a few class 2 applications to classes 4 and 5. There are several class 1 IETMs/ETMs but they were not included since they are more archival than active and not likely to be of importance in training. The class 2 and 3 IETMs are all for existing systems and equipment belonging to mature programs where existing manuals were used as the basis for developing the IETMs. The new programs, such as the Navy V-22 and the Air Force Joint STARS, are funded well enough to be developed at a class

4 level. Other programs, such as the Air Force F-16 and F-22 programs, are funded adequately to be developed at a class 5 level.

We were not able to identify consistent and specific criteria for decision making on what class a given IETM should be across the services. However, two other criteria stand out, beyond the criteria of funding availability and whether technical manuals are already in existence. One of these is the desirability of incorporating expert system technology into features such as diagnosis and coaching of technicians through troubleshooting. This is an especially relevant criteria where complex equipment failures are time critical or personnel may not be available with necessary skills for these activities. A second criteria is the desirability of integration of databases and applications in a total maintenance system. For the Army, for example, if the equipment has a bus system that will support integration with a total maintenance diagnostic system the IETM will be developed at a level 5.

The Army decisions about their desired IETM features illustrate how these criteria come into play and how those decisions can impact job definitions and the training required for the job. These decisions also illustrate how an IETM can be integrated with other applications. The Army has decided to combine ETM/IETMs with computer-aided diagnostics and test procedures to form a total maintenance system. In part, this is desirable because units such as trucks and tanks will often be forward of an organized maintenance capability and/or moving too quickly under adverse conditions to bring the equipment into a shop. Personnel on the vehicles cannot be trained for all maintenance situations without smart aids. Furthermore, the drawdown in the Army has resulted in fewer maintainers for more complex systems. Often consolidation of MOSs has not included more formal schooling, which means there is a need for more job performance support, especially in the field.

A family of equipment, included as part of standardization for automatic test systems, includes three versions of Contact Test Sets (CTSs) designated the AN/PSM-80(V). These three versions of CTSs are capable of not only connecting to equipment for test, measurement and diagnosis but also of delivering IETMs. All three are based on Intel i486 processor configurations. Version 1 is designed primarily to host delivery of ETMs/IETMs. Version 2 is also a self contained test and diagnostic system capable of connecting to a variety of vehicles through its interface cables. Version 3 is a self contained system primarily designed to be a generic automated weapon system tester. It is being used across a diverse group of systems including the Avenger missile system, Paladin Howitzer, and Abrams tank.

The treatment of IETMs as part of a total diagnostic system has been described by SAIC, a contractor who has developed many of the vehicle IETMs and diagnostic systems, as having the following capabilities:

- The host computer connects to the vehicle to be worked on and the IETM senses built-in test failure information

- If such information is present the IETM directs the user to the correct repair procedure.

- The host computer also connects to troubleshooting instruments and the IETM takes measures.

- Based on the measures the IETM directs the user to the correct maintenance procedure.

- The IETM automatically links to the correct entry in the RPSTL (Repair Parts and Special Tools List) which is normally another manual and would involve a task for another repair person.

- The IETM automatically inserts repair information into appropriate blocks of maintenance forms.

- The IETM assists in transmitting maintenance information to the Unit Level Logistics System.

Since each CTS costs from $15,0000-$20,000, it is expensive to outfit entire classrooms with them. However, the CTS design is flexible to allow standard Intel 486 based desktop computers to play the IETMs without the integrated diagnostic maintenance capability. The Patriot school, for example, only has a few CTSs for hands-on training and plays the IETMs on standard desktop PCs for the remainder of training.

The Air Force philosophy of integrated maintenance illustrates another way the criteria to design IETMs is used. The Air Force concept for maintenance is called Integrated Maintenance Information system (IMIS) and is part of the Air Force CALS initiative. IMIS was started for much the same reasons as the programs in the Navy and Army. There are more complex systems to maintain and more computerized maintenance aids for collecting data and diagnosing problems are needed.

One difference, shared by the Navy/Marine Corps and some Army air maintenance organizations, is the need to focus on aircraft maintenance. Therefore, the concept includes total integration from the time the aircraft is in flight and on-board diagnostics are running, to the aircrew debriefs on faults, scheduling of maintenance actions, status reporting, parts ordering, repair and troubleshooting. The technician uses a portable maintenance aid that contains ETMs/IETMs, diagnostics, training, and data collection capability. Data is downloaded from the aircraft to the portable device. The device/IETM displays inspection procedures to the technician, presents repair procedures tailored to the data, and performs operational checks to verify repairs. When the maintenance actions are complete IMIS transmits maintenance data collection reports and closes out work orders. IMIS also, conceptually, contains supplemental training material such as computer based instruction and collects training data from technicians interacting with that training although we were not able to confirm that is currently being done on any program.

A class 3 IETM cannot fulfill the IMIS concept. The IMIS concept requires class 4 and 5 IETMs because the units of information must be small and logically tied to the diagnostics system and other integrated aspects of IMIS. Further, the data base features and capabilities needed to integrate with other application databases move the IETM levels to class 4 or 5.

Classes 4 and 5 are without a doubt the IETMs that have the potential to redefine a job and, therefore, the training required. They may also have the greatest potential for integrated training elements. Unfortunately, they are also much more expensive than classes 1-3 and we are likely to see most IETMs developed at a class 3 level or lower.

3.2   Other Government and Industry SGML Documents

Arbortext (1995) estimates that business in this country produces 92 billion documents every year and that number is growing substantially. Managing and accessing that information is becoming an increasingly more difficult problem. Government agencies (non DoD) produce equivalent mountains of documents and share those problems. For that reason, several government agencies and industry groups/consortiums have initiated efforts to apply SGML technology to electronic documentation. This section discusses some of these efforts.

When we started the survey of industry, we were looking for IETM-type publications, whether SGML or not, that had training and education integrated or linked otherwise in some way. We also expected to find a number of Electronic Performance Support Systems (EPSS) with documents similar to IETMs that were integrated with training. With the exception of the air transportation industry, we did not find such efforts. Although there are a number of EPSS in place (Gery, 1991), they do not have large scale hypertext/hypermedia job documents as a major component integrated with training. Therefore, we only included SGML applications that might lead us to implications for integration of training in the survey.

Table 3 summarizes the projects we found. Further information on most of these can be obtained from an SGML Web site at http://www.sil.org/sgml/sgml.http. The applications shown in Table 3 include the air transportation industry, several federal government agencies, telecommunications industry, music publishing/business interests, electronic document publishers, software industry publications, news and newspaper industry, groups seeking to advance access to documents for print disabled people, and an electronic library of chemical society journals. We believe that there are many more, but these applications are certainly representative.

Of all the applications shown in Table 3, the first one, the Air Transportation Association (ATA), is the most relevant. The following description of efforts are taken from separate discussions with six Boeing employees, each in a different area of responsibility. We have taken the liberty of making a composite picture of what might be accomplished although there is apparently no explicit initiative to move in this direction now.

Boeing has two initiatives related to electronic manuals. Both of these are expected to be on-line around the end of 1995. One is associated with development of an ATA standard for electronic books including maintenance manuals and parts catalogs. This standard starts with defining SGML data elements, but adds the feature of Structured Full Text Query Language (SFTQL). The latter will be incorporated into a special DTD to define a query schema for the electronic books. The second initiative related to electronic manuals is to put the technical information in manuals in electronic form and distribute (download) them to portable maintenance aids in the field. This is the Integrated Technical System Initiative (ITSA), which is very much like the IETM concept. The computers will have customized search criteria to guide troubleshooting, defined through intelligence that is incorporated into the DTD and acted on by the viewer software. All COTS software, such as authoring software from Interleaf Corporation and EBTs Dynatext, is used to accomplish this.

Table 3

SGML Projects in Other Government Agencies and Industry

PROJECT NAME	BRIEF DESCRIPTION OF PROJECT
Air Transportation Association (ATA) Boeing Commercial Aircraft Company	Boeing has several related initiatives that are intended to result in the capability to distribute electronic manuals for maintenance of aircraft on the flight line as well as integrate with training in the classroom, simulators, and on-demand, just-in-time settings.
The Department of Energy (DOE) Office of Scientific and Technical Information (OSTI)	OSTI's activities include extensive use of SGML. "...One of the initiatives, for example, is the Department-wide effort to implement standards which will allow for the full-text electronic exchange of scientific and technical documents. OSTI also serves as the central point for the collection and sharing of scientific and technical information management activities of interest to DOE and its customers."
IPI-TCIF (Information Products Interchange/ Telecommunications Industry Forum)	Extracted from the IPI description file. dated August 1994 at *info.bellcore.com/pub/TCIF/ipi_desc.txt.* "The Information Products Interchange Committee addresses one of the largest, most widespread problems in the telecommunications industry - the vast amount of paper documentation associated with equipment used in the telecommunications network. With the ready availability of terminals, computers and publishing and retrieval systems for creating, viewing and managing documents in electronic form, delivery of the documentation electronically is a logical step." "When the Telecommunications Industry Forum (TCIF) precursor of the formal PI Committee began meeting, it was quickly apparent that most companies had dissimilar platforms, operating systems, work cultures and processes. No company could afford to abandon its investment in tools, and most felt their operation was appropriate for their circumstances. This meant that the members of a different committee needed to address recognized standards and develop guidelines that could support a diverse industry and support the emerging information technologies rather than to try to enforce standardization of tools." "The IPI Committee selected Standard Generalized Markup Language (SGML) as the standards for exchange of text. As steps toward implementing SGML, the committee has developed an SGML Document Type Definition (DTD), conducted document analysis for telecommunications procedural documents and successfully completed trial exchanges of documents in an SGML Format. The committee also works with Bellcore on the development of Generic Requirements Documents on SGML."
SMDL - Standard Music Description Language, ISO/IEC DIS 10743: 1995	Extracted from [July 1995] DIS (FTP.ORNL.GOV/PUB/SGML/WG8/SMDL/10743: "This International Standard defines an architecture for the representation of music information, either alone or in conjunction with text, graphics, or other information needed for publishing or business purposes. Multimedia time sequencing information is also supported. The architecture is known as the "Standard Music Description Language", or "SMDL". // SMDL is a "Hy-Time" application, it conforms to International Standard ISO/IEC 10744 - Hypermedia / Time-based Structuring Language ("HyTime"). Specifically, SMDL is a "derived architecture" derived from HyTime architecture"
IRS (US Internal Revenue Service)	A large number of IRS documents are available in SGML format in the IRS-SGML Library on the FedWorld Information Network. The SGML documents are complete with DTD. The IRS-SGML Library had some 90 documents as of April 11, 1995, and the list is said to be "updated each morning." The documents are encapsulated in self-extracting binary files (".EXE" MS-DOS compressed files).

Table 3 (Continued)

PROJECT NAME	BRIEF DESCRIPTION OF PROJECT
Association of American Publishers (AAP) Electronic Publishing Special Interest Group (EPSIG)	EPSIG was invited by the AAP to carry out development and promotion of the EPSIG/ AAP "Electronic Manuscript Standard" for the preparation, publication and interchange of electronic manuscripts. The most visible element of the new EPSIG's charter is to be the "voice" of "ISO12083: 1993," reporting on implementation, modification, and evolution. In (about) early 1994, the sponsorship of the Electronic Publishing Special Interest Group (EPSIG) was transferred from OCLC [On-line Computer Library Center] to management under three collaborating entities. These are: the Association of American Publishers (AAP) [supplies direction for SGML requirements of the AAP membership], the Graphic Communications Association Research Institute (GCARI) [organizational management], and McAffe & McAdam, Ltd [technical direction].
Davenport Group [DocBook DTD]	The DocBook DTD was developed specifically for computer software documentation, that is, user manuals and programming references. DocBook maintenance is performed under the aegis of the Davenport Group, a discussion forum sponsored by individuals representing large-scale producers and consumers of software documentation. Davenport meetings are held roughly quarterly, and are open to everyone. However, decisions about the DocBook DTD are made only after approval by the Davenport sponsors. As of 11 August 1995, the Davenport sponsors were: Novell, Fujitsu OSSI, Digital Equipment Corporation, SunSoft, Hewlett-Packard, Arbortext, SoftOuad, Hitachi Computer Products, SCO, O'Reilly & Associates
CADD: International Committee on Accessible Document Design	SGML is being used by various entities supporting ICADD because the document structure captured in SGML is vital in the communication processes designed for persons with print disabilities. ICADD Statement of Purpose: The International Committee for Accessible Document Design (ICADD) is dedicated to making printed materials accessible to persons with print disabilities. ICADD is an international nonpartisan consortium of representatives from industry, education, and the disabled community. We believe that advancing computer based publishing, through adaptive computer technology for persons with disabilities, offers the potential to make printed information accessible simultaneously and at no greater cost than the able bodied community enjoys."
UTF (Universal Text Format) - SGML for the News Distribution Industry	UTF ("Universal Text Format") is the name of a new standard being adopted by the news distribution industry, and particularly, under the direction of working committees in the IPTC (International Press Telecommunications Council) and NAA (Newspaper Association of America). UTF is part of The Information Interchange Model (IIM) standard. Description from a working document on UTF by Dave Becker: "In June, 1992, a working subcommittee was established to create an industry standard for the interchange of textual material between news agencies and their clients (primarily newspapers) that would replace the current standard IPTC 7901 and ANPA 1312 formats. The new standard is called the Universal Text Format (U1T). After significant discussion, SGML was adopted as the encoding language for the new standard. Members of the working subcommittee are now attempting to finalize and prototype the new standard in selected test environments. "
CAPS: Communication and Access to Information for Persons with Special Needs	The CAPS project has developed a DTD for newspapers

Table 3 (Continued)

PROJECT NAME	BRIEF DESCRIPTION OF PROJECT
SEC (Securities Exchange Commission) EDGAR Database	SGML Markup EDGAR filings
The OCLC (On Line Computer Center) CORE Project	The CORE project is an electronic library prototype that provides networked access to the full text and graphics content of the American Chemical Society journals and associated Chemical Abstracts Services indexing since 1980 (some 250 journal years of data). The database is coded in SGML (Standard Generalized Markup Language) which was translated from the original typography codes, captures the structural richness of the original document and provides flexibility for indexing, searching and display. The prototype provides a full-scale laboratory environment in which to explore l issues of database structure, user interface capabilities, and information retrieval l questions on a large, real-world scholarly electronic journal database. The complete database, representing more than 600,000 pages of full text and graphics, will be available at Cornell University in late 1994. The major contributors of this electronic library project include: Cornell University (Mann Library); OCLC; Bellcore; American Chemical Society; Chemical Abstracts Services."

While the primary reason for moving to electronic manuals in the aircraft industry is the desire to eliminate the cost and problems of paper management, they have recognized that they have the opportunity to deliver just-in-time training through the same technology. Another initiative will incorporate SGML based documents for training on the flight line. This effort is in the planning stage for a prototype. This training is not intended to take the place of classrooms and simulators, especially for initial training. As pointed out by one of the interviewees, classroom training focuses on principles and has less details whereas the just-in-time training envisioned for the field focuses on the details. To accomplish this, some people from the training departments are involved in the electronic manual development. High level management is committed to the integration of electronic books and training as part of ITSI.

Other aspects of new Boeing training initiatives and planning, some of which support moving training from the classroom to a just-in-time setting, are development of paper workbooks with bar code testing devices, computer-based training (CBT), distance learning, and collaborative learning. Most of the current maintenance training is held in a classroom setting. For example, the Aviation Industry CBT Committee (AICC) has been looking at object-oriented authoring and studying what structure is needed for a data base to support putting instruction on hand held devices outside the instructor led classroom environment. In part, this initiative is also oriented toward integrating the documentation and training worlds. As pointed out by another interviewee we are changing the paradigm of what we think of as training and must redefine when and what training is related to such capabilities as smart documents, on-demand training and just-in-time training.

3.3   SGML Applications in Higher Education

Most of the applications found in higher education relate less to IETMs per se and more to the use of SGML and other aspects of IETM technology for case-based (Kolodner, 1993; Montague, 1994) military education including complex, advanced learning such as weapon system acquisition, weapon system management, joint force planning, and military strategy and tactics. Case-based instruction provides the learner with a meaningful, real world context by which to anchor new knowledge and promote transfer of using that knowledge in new situations. Case-based instruction is often thought of as a classroom-based technique, but it is sometimes incorporated into CBT as well. We see the value of converting case studies in such areas to structured SGML electronic documents that provide smart tools for the learner to navigate, search and link relevant case material as they plan, design and solve problems. While such electronic documents can be expected to enhance learning, they can also be made available outside the classroom environment perhaps through facilities at networked schools such as the various military academies and post graduate schools and even the World Wide Web.

Most of the SGML applications found in higher education are designed to support scholarly research efforts in the humanities, literature, arts, and other content domains. A great deal of work is being done by university libraries as part of movements to make electronic documents available for scholarly research. Of special interest here is the work being done to make the documents more readily accessible via an interface that is meaningful to the scholar. This meaningful interface can translate to support for a learner in a case-based, SGML encoded learning environment. For example, the LETRS (Library Electronic Text Resource Service) at Indiana University is designed to support access to large text documents by humanist scholars in the way that they tend to ask

questions. This focus on the particular scholars mental model for asking questions is an important way to approach design and structuring of the documents.

Another example of user interface consideration is the Rossitti Archive, at the Institute for Advanced Technology in the Humanities (IATH). It is a hypermedia environment encoded with SGML for studying the works of a poet and painter. This application illustrates the display of SGML based hypermedia with annotations and notes from experts. The same technique could be applied to military case-based education and training. Software developed by the IATH represents still other aspects of the learner interface that are relevant to military case based learning. It provides an SGML-aware synoptic tool that can display multiple texts in linkable parallel windows, It will allow multilingual texts to be displayed simultaneously. Users will be able to link the texts for scrolling and searching. This capability would allow a learner to build new displays and files that connect information related to a case or problem given in a learning environment.

Further information on the applications shown in Table 4 is available through the SGML Web site at http://www.sil.org/sgml/sgml.http.

Table 4

Higher Education Applications of SGML Technology

PROJECT NAME	BRIEF DESCRIPTION OF PROJECT
Text Encoding Initiative (TEI)	The TEI has developed an SGML encoding for a wide range of document types in the domain of humanities computing. The Text Encoding Initiative is an international research project sponsored by the Association for Computing in the Humanities (ACH), the Association for Literary and Linguistic Computing (ALLC), and the Association for Computational Linguistics (ACL). Funding has been provided in part by the US National Endowment for the Humanities, Directorate XIII of the Commission of the European Communities, the Andrew W. Mellon Foundation, and the Social Science and Humanities Research Council of Canada. The TEI ("P3") Guidelines were published in May 1994, after six years of development involving many hundreds of scholars from different academic disciplines worldwide.
Oxford Text Archive (OTA)	The Oxford Text Archive has sponsored extensive research involving the use of SGML in an academic setting. A catalog of electronic texts in the Archive is available in SGML format. OTA is also the authoritative FTP site for a significant corpus of literary texts encoded in (TEI) SGML by members of the Oxford Text Archive project and by others.
University of Michigan	The Humanities Text Initiative (HTI) is a project of the University of Michigan Libraries, the UM Press, and the School of Library and Information Studies, with support from the College of Literature, Science & Arts. The HTI is responsible for creating and maintaining new textual collections, primarily in TEI SGML.
University of Virginia Electronic Text Center	The University of Virginia has pioneered a number of successful uses of TEI SGML in delivering on-line electronic texts, including structured-text searches. "The Electronic Text Center at the University of Virginia combines an on-line archive of thousands of SGML-encoded electronic texts with a library-based Center housing hardware and software suitable for the creation and analysis of text. Through ongoing training sessions and support of individual teaching and research projects, the Center is building a diverse and expanding user community locally, and providing a potential model for similar enterprises at other institutions. "(from the ETC home page)
Brown University Scholarly Technology Group (STG)	STG "supports the development and use of advanced information technology in academic research, teaching, and scholarly communication. SGML is used in several aspects of STG work, and most visibly in the Women Writers Project. The Women Writers Project is creating a full-text database of women's writing in English from the period 1330-1830. Texts are encoded in TEI SGML.
British National Corpus Project (BNC)	The BNC is a large (100 million words) corpus of modern English, both spoken and written, produced by an academic/industrial consortium lead by Oxford University Press, involving Longman UK Ltd, Chambers/Larousse, Oxford University Computing Services, the University of Lancaster and the British Library. Production of the corpus was funded by the commercial partners and by the UK Government, under the DTI/ SERC Joint Framework for Information Technology." The corpus is encoded according to the TEI (Text Encoding Initiatives Guidelines, using the ISO standard SGML to represent this and a variety of other structural properties of texts (e.g. headings, paragraphs, lists etc.). Full classification, contextual and bibliographic information is also included with each text in the form of a TEI conferment header file."

Table 4 (Continued)

PROJECT NAME	BRIEF DESCRIPTION OF PROJECT
(Library Electronic Text Resource Service) LETRS Indiana University	LETRS provides on-line access to SGML tagged texts. LETRS supports the rapid indexing, searching, retrieving, and navigating of large, structured, full text files in ways relevant to the types of questions that humanists ask about texts. Texts are tagged in SGML (Standard Generalized Markup Language) and conform to the TEI (Text Encoding Initiative) implementation of that standard.
Institute for Advanced Technology in the Humanities (IATH) University of Virginia at Charlottesville	Several IATH projects use SGML encoding in the preparation of electronic scholarly text editions. Software developed under IATH auspices has occasionally been released as well. For example, in early 1995, IATH announced Babble: a synoptic text viewer. Currently under development, it will be an SGML-aware synoptic text tool that can display multiple texts in linkable parallel windows. It will allow multilingual texts to be displayed simultaneously. Users will be able to link the texts for scrolling and searching.
IATH: Rossetti Archive	The Rossetti Archive at IATH features the writings and pictures of Rossetti encoded in SGML. The Rossetti Archive is a hypermedia environment for studying the works of the Pre-Raphaelite poet and painter Dante Gabriel Rossetti (1828-1882). The archive is a structured database holding digitized images of Rossetti's works in their original documentary forms. Rossetti's poetical manuscripts, early printed texts - including proofs and first editions - as well as his drawings and paintings are stored in the archive, in full color as needed. The materials are marked up for electronic search and analysis, and they are supplied with full scholarly annotations and notes
Center for Electronic Texts in the Humanities (CETH) Rutgers University, New Brunswick, New Jersey	CETH is sponsored jointly by Rutgers, the State University of New Jersey and Princeton University. CETH acts as a national focus for the creation, dissemination and use of electronic texts in the humanities with emphasis on scholarly applications and primary source materials. CETH's activities include an Inventory of Electronic Texts in the Humanities and research into methods of providing Internet access to collections of SGML-encoded material in the humanities. In particular, CETH has promoted the study and use of the TEI (SGML) header as a form of authentication in cataloging electronic texts by libraries and archive centers.
Berkeley - Berkeley Finding Aid Project University of California at Berkeley	With assistance from Electronic Book Technologies' Educational Grant Program and the NEH (Act Title IIA Research and Demonstration Grant. October 1993 - September 1995), the project is sponsoring advanced research in SGML technologies for use by electronic libraries. Finding aids are documents used to describe, control, and provide access to collections of related materials. In the hierarchical structure of collection level information access and navigation, finding aids reside between bibliographic records and the primary source materials.

Table 4 (Continued)

PROJECT NAME	BRIEF DESCRIPTION OF PROJECT
Project ELSA (Electronic Library SGML Applications)	Project ELSA is carrying out research into the use of documents in libraries which have been marked up in SGML format (Standard Generalized Markup Language). The project will construct an electronic store of documents which will take the form of a server on a network. Client computers will be able to access the material on the server, download it and make it available to librarians and end users for use and manipulation. The project is funded through European Commission DG XIII and has three partners. Jouve System D'Information (France) the lead partner, will provide the search engine, user interface software and client server software, Elsevier Science (Netherlands) will provide the documents and De Montfort University will develop the user interface and provide a test bed.
UCLA - InfoUCLA Project	The UCLA information processing group has been experimenting with SGML,(Standard Generalized Markup Language) as a way to publish its data so that it can be accessed in a variety of ways, one of which is via the International Committee for Accessible Document Design (ICADD) document type definition, which through the use of enabling technologies makes electronic information accessible to people with disabilities.

Section Four

Integration of IETMs with Training and Education

4.0   Integration of IETMs with Training and Education

The focus in this report now turns to the training of technicians with IETMs as a primary media and content resource. Since technical manuals, whether paper or electronic, usually form a major basis in training programs for learning how to perform tasks and apply knowledge, it is expected that introducing IETMs into training will change things.

4.1   IETM Training Settings

These changes will be discussed within the context of the traditional and electronic classroom; the movement of training out of the classroom to on demand, just-in-time training; and the reduction of training by increasing the IETMs role as job aids. Each of these has been a reaction to the conceptual nature of IETMs and is now a path being taken. Since they represent quite different approaches it is worth examining the rationale and potential of each. Regardless of the approach, it can be said with certainty that IETMs have changed the way documentation organizations do their work and will change the way training organizations do business as well.

4.1.1   IETMs in the Classroom

As discussed previously, the early rationale for IETMs centered on improving the documentation system. Improving technician proficiency and thereby increasing maintenance effectiveness also became a goal when the IETMs were defined with interactive, job aiding features. It soon became apparent that if these job aiding electronic documents could increase maintenance technician effectiveness, even to the point of bringing novices to the level of more experienced people, there might be an impact on the training needed. That is, maybe the time required to train could be reduced thereby reducing training costs and increasing availability of people to perform jobs. For example, a 33% reduction in the number of training courses required and a 28% reduction in the number of training days was estimated for technicians of one large weapon system training program (Alligood, 1994). With those goals as an incentive, attention has recently turned to the technicians formal training programs.

Much of the training of military technicians occurs in centralized schoolhouses where the facilities and other resources, such as instructors and laboratory equipment, can be made available. In most cases, the instruction occurs in combinations of classroom and laboratories. The traditional classrooms are typically instructor-led with lectures, demonstrations, and whatever interaction with students time allows. The introduction of IETMs means putting computers in the classrooms and laboratories. We will discuss the planning and logistical requirements associated with installing computers in the classrooms in Section 4.2. In the remainder of this section, we will focus on the impact on the instructional nature of the classroom.

The introduction of computers into the classrooms and laboratories, for the purpose of supporting instruction using IETMs, also parallels the movement towards the electronic classroom. There has been, over the past few years, much interest in the electronic classroom in the military, business and industry training, and in the educational sectors at all levels. By electronic classroom we mean the use of computers and communications to support the development, access, and management of learning resources and events.

During a recent survey of electronic classrooms (Kribs, 1994), we found intense activity in the military and some of these were linked to the coming of IETMs into the training programs. Since the IETMs and, therefore, computers would be used in the training program a number of questions naturally arose. For example, how can an instructor control and monitor the activities at each student station? How can an instructor use the IETMs to display specific electronic information such as pictures, graphs and tables, to the class? How can the IETM material be augmented with instructional material such as additional graphics, animations and photos which the instructors would like to use? What additional functions can the computers perform, such as testing and record keeping, remediation, interactive courseware, and collaborative learning? These questions are being addressed and IETM-based electronic classrooms are gradually being redefined and extended to meet the needs

Our survey of electronic classrooms, along with work by others, has demonstrated that there is no single definition of an electronic classroom that fits all situations. Furthermore, we believe that concepts of electronic classrooms will and should evolve. Several close observers of electronic classrooms in the educational sector have recently commented on the variations in definitions and the possible transformation of educational practices and organizations as a result of technology. Plater (1995) of Indiana University Purdue University, for example, has noted that the term has become such a symbol of change in education that it is often used to even describe pseudo-electronic classrooms that consist only of a large amount of technology, sufficient to emulate some interactivity and communication but which lack the communication and connectivity processes students and teachers really need. As Plater points out, however, by any definition the first electronic classroom in any organization should be viewed as the beginning of a process that may change the institution. He offers four categories of change which should be considered: (1) when, where, and how people learn; (2) what and why they learn; (3) the evolving role of the faculty (toward enabling students to learn themselves rather than as transmitters of knowledge); and (4) the future of the institution itself.

Similarly, Connick and Russo (1995) of the Education Network of Maine argue that technologies, such as telecommunications, challenge the fundamental tenets upon which our entire educational system has been constructed (p 15). They point to the changing need to aggregate people simply to communicate with them and the movement toward learner-centered learning environments. Whether one agrees fully with these practitioners, it is still obvious that experience with IETM based electronic classrooms will suggest changes in the way we do business. Virtual classrooms are a distinct future possibility for IETM based training as the movement toward a more learner centered electronic classroom progresses.

To some extent, the current mental model of the classroom as an instructor led, on-the-podium, group learning setting is now being simply transferred over to the IETM-based electronic classrooms. We do not argue against this as a first step, but suggest that changes in student learning and the instructor roles may be worth considering in the next few years. A recent Issue Paper by staff at the Navy's Service School Command, Great Lakes (Fretz, 1995) illustrates one thought on this topic based on the lessons learned from one of the first IETM based electronic classrooms. A computer classroom can be more than an enhancement of the classic group paced instruction (GPI). Computers are best used to present self-paced instruction with the instructor becoming a moderator and mentor. Our IETM [-based classroom] followed the GPI mold due to curriculum control

concerns, the cost of developing 15 weeks of quality self-paced instructional modules (ICW), and the primary objective of taming the paper tiger first and breaking the paradigm second (p. 1). It is suggested that not only can the instructors role change but so can the students. The IETM-based electronic classroom can be structured for students to take more responsibility for themselves and with each other.

A recent development that should be of interest to all who are involved with electronic classrooms is going on at the Navy's Great Lakes Service School Command. The Training Integration Management Software (TIMS, formerly called the Annotation Manager) is being developed by the contractor System Engineering Associates under the Classroom Automation System research program at the Navy Personnel Research and Development Center. TIMS is designed to provide instructors with the ability to personalize the curricula, as well as integrate and operate the variety of windows-based applications in the classroom. For example, TIMs provides the facilities to control classroom multimedia and IETM presentations. Instructors can alsouse TIMS functions to personalize a standard instructor guides with text and other digital media forms. TIMS allows linking IETMs to the standard instructor guide so that the instructor can instantly launch the IETM viewer at the place desired in the curriculum. TIMS uses the standard Windows communication facilities, such as dynamic data exchange (DDE) that allows applications to exchange data. It is written in Microsoft Visual Basic with some third party DLLs (dynamic-link libraries).

4.1.2 IETMs in On-Demand and Just-In-Time Training

The IETM-based electronic classroom, according to estimates by several Navy sources, is anticipated to result in fewer courses and less training time. This new form of the classroom will also result in changes in the roles of instructors and students. In addition, it can be expected that the definition of the classroom will continue to change as its functionality is enhanced by the new technology available. The virtual classroom may be one of those ways it changes. The networked virtual classroom, whether for physically co-located groups or physically separated individuals, offers the promise of distributing the instruction to more people with less instructor resources.

Several military agencies responsible for the implementation of IETMs and training are studying the option to move more training out of the classroom by supporting performance in the field with smart IETMs and computer based training (CBT) that can be accessed as needed. Although no organization we surveyed was considering total elimination of classrooms and associated laboratories, especially for initial training of apprentices, there was a definite inclination to reduce the formal, centralized school time. This initiative revolves around the concept of just-in-time training with a performance support system. Just-in-time training seems especially to be a focus for the military and industry areas of aircraft maintenance. Both the Navy and Air Force are planning for IETMs and CBT as a means of providing technicians performance support on the flight line and for in-service training. Several of the major aircraft manufacturers we surveyed are also developing SGML based electronic documents, with intelligence, to aid their customers technicians on the flight line. These electronic documents are also part of a total concept of a performance support system that includes computer based training.

There are three points we want to mention briefly in association with just-in-time training performance support systems. First, part of this concept is the idea of an integrated data base of

technical information that can be used for both documentation and training application software. That is, the integration of technical information needed for both maintenance and training can reduce redundancy in both development and configuration management efforts, allow more timely updates of both the documentation and the training in concert, and permit one agent to manage the data base. Second, the possibility exists to generate the CBT, or at least a first iteration of it, from the technical information of the data base. Both of these will be discussed further. Third, the concept of such a performance support system raises interesting questions about the assessment of effectiveness. How do we know which component of the performance support system is working or not working when data is gathered to assess performance itself? We suggest that assessment evaluation needs to be part of the total system.

4.1.3 IETMs as Expert Job Aids

Several of the organizations interviewed expressed strong preference for moving the capability to support the technician more via the IETMs and providing whatever training is needed in the field. The Army, for example, is faced with the prospect of a fast moving set of vehicles racing across land well beyond reach of expert maintainers and their logistical resources. The more intelligence that can be put into an IETM the better the operators of the equipment can be supported to fix what breaks. In fact, this has been extended in several cases to provide higher levels of automation in the troubleshooting and repair process.

As described in our review of IETMs in the military, the Army is developing many IETMs that are embedded into a diagnostic system. That is, the IETM computer connects to the equipment being worked on and the IETM senses built-in-test information to direct the technician to the correct repair procedure. The IETM computer also connects to troubleshooting instruments to allow sensing readings and provide direction of the use of the instruments as part of the repair process. When the IETM has identified the component to be replaced, it displays and guides the technician through the correct procedure. The IETM then automatically links to the correct entry in the repair parts and special tools list (usually another manual the technician must use). Finally, the IETM automates the filling out of maintenance records and sets up the basis for transmitting that information to the logistics system later. This is certainly a redefinition of jobs and training requirements as a result of IETM technology.

However, we note that not all IETMs will have such a capability. The cost of developing class 4 and 5 IETMs, versus class 3, may be a stumbling block. The economics of IETMs is beyond the scope of this report, but we hesitate to suggest that a large number of smart documents can be built in the near future to impact a wide number of jobs. Many IETMs for mature systems will lack the smart performance support features and will not be electronically integrated into a total maintenance system.

4.2 Implications for the Organizations

In the broad sense, technology is not only hardware and software. It is knowledge and techniques about how to accomplish a goal. These have implications for coordinating task performance within organizations. One relevant way to characterize technological impacts on organizations (Kast & Rosenzweig, 1974) is to consider three aspects that affect the organizations coordination structure. These characteristics are linking, mediating, and intensive. A technology is

44

linked when there is a serial interdependence between units of work activities. An assembly line is the classic case of linked technology. A mediating technology is one that requires an interchange among individuals who are otherwise independent. Home television shopping is a new mediating technology between consumers and those who have products to sell. An intensive technology is one that requires use of a variety of techniques, perhaps from different specialties, in order to achieve goals.

IETM technology and the integration of IETMs with training and education represent all three of these characteristics. There is an interdependence in the flow of maintenance, documentation and training activities so the technology is linked. It is mediated because, in each stage of the life cycle for several products, developmental personnel must interface with personnel in other stages and within stages, as well as with the end-user. It is intensive because it draws upon several disciplines: maintenance, logistics, documentation, and training each with both unique and common basis for technology. The integration of IETM technology into training and education, therefore, requires a look at the coordination roles and functions of organizations.

There appears to be evidence that training and documentation organizations will need to change at several levels. Typically in the past, large organizations inside and outside the military have had one unit which took care of documentation and one responsible for developing and operating training. Because of the impact on both areas it will be necessary for even greater coordination between the agencies and, most likely, an integration of the agencies at least for the purpose of developing and managing IETMs. This will be especially true if the path of an integrated data base is taken.

We have already discussed the expected changes in how training is conducted in the classroom at the schoolhouse level. We expect that this will also impact the schoolhouse organization as instructors become managers of learning resources more than authorities in content that have been trained to lecture and demonstrate. There is also an impact on course management and the organizations responsible for specifying, developing, and evaluating those courses. It is beyond the scope of this effort, and the abilities of the authors, to redesign the organizations involved. We offer some further thoughts on organizational elements and coordination below based on discussions with people in the survey.

4.2.1 Coordinated Definition and Development of IETMs

In most cases it seemed that the training organizations who would be receiving IETMs were involved at least at a cursory level in the definition and development of IETMs. In some cases, schoolhouse personnel played a part in the development. However, more often it appeared that the definition of the class of IETM, especially in new weapon systems, and the resulting impact on training requirements was not a systematically coordinated effort. It is also unclear how logistic task analysis and Navy Training Plan development play a part in the definition and design of IETMs. To date, it appears that the same paper documentation policies and procedures are being followed.

4.2.2 Course Management

With the rapid evolution in technologies and advances in system capabilities, the analysis of management requirements should be viewed as an ongoing process both during and after implementation. In some cases, the changes in management requirements may simplify procedures, reduce time and effort, or make more efficient use of facility space. In other cases, the changes may add a number of new functions to be performed and requirements to be supported, require personnel training for new skills, dictate a different mix of personnel, or increase time and effort. All of these changes have cost implications that must be addressed as part of the decision making and planning process.

Implementation of the new technology in just one course in one classroom in a schoolhouse can have consequences that extend beyond that classroom. For the most part, the management requirements for the IETM based electronic classroom are very different from a traditional classroom and have implications for: (1) the school/course management organization and its structure, policies, and procedures, (2) the instructors and their duties, (3) the roles and responsibilities of management, administrative, and support personnel, and (4) the facilities and their utilization. NAVEDTRA 135, Navy School Management Manual, defines the processes, procedures and documentation required for management of NAVEDTRACOM schools. It is expected that as greater coordination of efforts among logistics, maintenance, documentation and training communities is achieved the policies and procedures set forth in that document will be revised.

4.2.3 Planning

Although adequate planning is essential, the process normally required for planning and implementing such technology is too long and time consuming. Often times the technology is obsolete before the system is installed. Management tools need to be developed to support the planning and budgeting phase and facilitate the acquisition and installation phase. For example, NAVSEA has tasked personnel at the Fleet Technical Support Center, Atlantic (FTSC-LANT) to develop a generic Equipment Facilities Requirement Plan (EFRP) and a generic Abbreviated System Decision Paper (ASDP) for use in planning and initiating future implementations. The purpose of these generic documents is to serve as guidelines identifying the basic requirements and indicating where school specific information needs to be furnished.

Likewise, personnel from the Naval Sea Systems Command Automated Data Systems Activity (SEAADSA), the Hardware Installation Activity for the Gas Turbine IETM implementation at Service School Command, Great Lakes (SSC GLAKES), discussed the requirement to streamline the process for procuring the electronic classroom components. Efforts are underway to establish a delivery order type contract to allow schools to acquire COTS hardware and software (i.e., the LINK System and the LiveBoard) that are specified as part of the configuration and are not available under the current small multi-user computer contract or GSA schedules. This type of contract may include provisions for quantity buys, spares, installation and maintenance support, and user training. It should result in lower acquisition costs and reduce the lead time to order and install the equipment.

Adequate planning is key to successful implementation of the IETM/AC technology. As documented in a paper presented by the Gas Turbine (GS) Technical Training Officer, LT. Eric Fretz (1995), the speed with which the technology was implemented in the GS School led to some early mistakes that could be avoided by more planning and discussion. For example, the size of automated classrooms was decreased to a maximum of 12 to 15 students from the maximum of 25 students in a paper-based classroom. The classroom size has implications for supporting the projected student throughput as well as classroom scheduling and system resource management. To meet projected throughput requirements, the electrical GS school has three classrooms with 12 student stations each, the mechanical GS school has one classroom with 15 student stations, and both schools share one classroom with 12 student stations.

Also, the initial SSC GLAKES hardware and software configuration did not include the use of a local area network (LAN) to link the instructor station (server) and the student stations (clients) in the classroom. When this requirement was recognized, an EtherNet LAN and Windows for Work Groups 3.11 were installed. However, this simple setup does not provide the necessary capabilities and security features so plans are currently being made to upgrade to Windows NT software. Physical security of the classrooms and management of the COTS software inventory are major concerns that need to be addressed in addition to maintaining the integrity of the instructor station configuration and the security of the course tests.

4.2.4 Life Cycle Support

Life cycle management and support is impacted by the technology and requires new organizational elements from both training and acquisition commands For example, NAVSEA has recently tasked the several organizations to define the life cycle management and support requirements for the five electronic classrooms at the GS schools. The specification of life cycle support requirements for the IETM electronic classrooms is evolving as problems and potential solutions are identified.

SEAADSA was designated as the Hardware In-Service Engineering Activity (ISEA) and the Basic Software ISEA for the classrooms. The term hardware is broken down into two definitions. Computer hardware is defined as any piece of physical equipment including computers, monitors, desks, and chairs. Non-computer hardware is defined as any piece of physical equipment related to hotel services (i.e., lighting, electrical power, heating/air conditioning) that is necessary for the proper operation of the IETM electronic classroom configuration. Basic software is defined as any computer program or collective group of programs that contribute to the operation of the IETM/AC (i.e., Windows and other standard software that may be loaded on the system at the time of purchase). SEAADSA is responsible for coordinating any changes in the hardware and basic software configuration for the GS classrooms.

The Naval Sea Logistics Center, Code 30 (SEALOG) was designated as the Hardware and Basic Software Life Cycle Manager (Hardware LCM). Personnel are in the process of preparing a Life Cycle Management Plan that documents the responsibilities and tasks for supporting the classrooms over their life cycle. FTSC-LANT was designated as the Software ISEA. Personnel are in the process of preparing a Software Life Cycle Management Plan that documents the responsibilities and tasks for supporting the software configuration. SSC GLAKES, as the end user of the IETM electronic classroom technology, is responsible for monitoring the condition of the

hardware and software configuration, ensuring appropriate maintenance actions are taken, and coordinating with SEAADSA, SEALOG, and FTSC-LANT on life cycle support issues for the classrooms.

Based on the GS school experience, it is clear that implementation of the technology imposes additional personnel support requirements on the schoolhouse. Some personnel support is provided by vendors and contractors involved in the effort. However, most of the personnel support for the automated classrooms comes from the school managers, course supervisors and instructors with assistance from the New Technologies Division staff. Therefore, the GS "C" School managers are preparing an ASDP for submission to the Naval Education and Training Program Management Support Activity (NETPMSA) to address the additional support requirements over the life cycle of the IETM electronic classrooms.

4.2.5 Instructor, Student, and Staff Training

Only two military IETM applications, shown earlier in Table 2, had enough experience with integration of IETMs into a formal training program to identify what was needed for both preparing instructors and students to successfully use the technology in the classroom. The two schools were the Army's Air Defense School, 6th Brigade at Ft. Bliss, which covers Patriot Missile military occupational specialties (MOS), and the Gas Turbine Technician courses at the Service School Command, Great Lakes. In both cases, the lessons learned were clearly similar and significant. Instructors need a formal training course. Students need training to use the IETM and any associated electronic classroom technology embedded into their regular course of instruction. Basic computer literacy in a Microsoft Windows environment cannot be assumed to be the norm.

The training at Ft. Bliss is conducted by the U.S Army Missile Command, Integrated Material Management Center (IMMC). IMMC also supports the IADS (Interactive Authoring and Display System) used to develop and present missile command IETMs. The same authoring software is used in the schools by instructors to develop and personalize plans of instruction (POIs). Therefore, although the IMMC courses are described as authoring courses, they cover some of the same content that will be described below for the instructors at Great Lakes. IMMC offers courses ranging from a two day authoring overview to a week-long detailed authoring tutorial. Since IMMCs IADS customers may be located anywhere the courses are offered at IMMCs home base at Redstone Arsenal or at the customers facilities.

The recent course offered for Patriot Missile instructors provided 105 Senior NCO, NCO and civilian instructors with a two and one-half day basic course on the use of IADS to author and link POIs into both IETMs and instructor produced materials from the POIs. Training was provided on how to navigate the IETMs and find the names of text units and graphics. Material developed by COTS tools, such as the schools use of Asymmetric Toolbook, can be launched by IADS as indicated in the POIs. Training for use of COTS development tools was not included in this course. The instruction included linking to graphics, multilinking from text to text passages, and conditional branching to modify displays. Instructor specific techniques, as opposed to standardized POI links required by everyone, for incorporating materials into the courses was also covered. All of these instructor activities in the POI lesson plans are invisible to the students, who also have the lesson plans at their stations. The display to students occurs at their stations as well as on a large screen display under instructor control via his/her POI.

The course, at two and one-half days was found to be of adequate length for those instructors who were proficient in the use of Microsoft Windows However, others had trouble. In fact, IMMC has found that here is a large cultural hurdle for the older Senior NCOs who have spent many years as podium-based instructors. They may see IETM technology as a threat and may also be somewhat computer-phobic. Younger instructors seemed to have less trouble generally, but this also posed a threat to Senior NCOs. It appears that the course assumes a prerequisite level of proficiency in Microsoft Windows. Those not familiar with Windows-based systems need instruction on all of the basics of operating the computers. The course instructors have attempted to include such instruction, but there is insufficient time to bring those personnel up to the level needed.

Student training on the use of the IETM classroom technology was also required in the Patriot Missile courses. It has been incorporated in an ongoing manner, as opposed to up front, in the courses. Most students lack basic computer literacy skills. This also has meant that efforts need to be made to teach instructors to train the students in these basic computer skills. As expressed during one interview with an IMMC representative it would be highly desirable for students to have been given these skills early in their Army training, perhaps before initial MOS training. Instructors at the Patriot Missile school have found that management of the students is impossible without having a large screen display to help guide the students through the exercises they are to complete during class. In addition, it is typical to have two instructors so that one can walk around the classroom looking for problems and providing individual guidance as may be needed. Thus, tools for instructor management of students can go beyond support for learning the content area and include support for learning basic computer skills.

In the Gas Turbine courses at SSC GLAKES, the level of computer literacy among students is also variable and a large percentage of students do not have sufficient basic Windows computer skills. On the first day of class, students receive approximately six hours of training on Windows-based skills required for the IETM and electronic classroom. The training varies depending on the students familiarity with computers. Novices are directed to go through the mouse and Windows tutorials before being introduced to the IETM on-line help index and practicing navigating through the IETM. Students concentrate on searching the database, making annotations, and creating bookmarks. Instructors report that most students are comfortable with the system and proficient in using it by the end of the first week of class. Students that continue to have trouble may receive additional assistance during the voluntary study time.

Students have the capability to use the annotation feature in the IETM database to take notes on-line at their work stations during class sessions. However, there appear to be several drawbacks to on-line note taking. Many students do not have basic typing skills and hunting and pecking on the keyboard disrupts their concentration on the course content. Since the only systems available for students to review their notes on floppy disk are the ones in the IETM classrooms, their study time is restricted to the afternoon hours. They do not have access to systems after hours or over weekends. Likewise, the students may not be able to review their notes on-line after they return to their jobs in the fleet.

To maximize the effectiveness of the IETM and electronic classroom technology at SSC GLAKES, the instructors must be adequately trained on the operational features and enhanced capabilities of the technology. Since the instructional staff has varying degrees of computer literacy

and experience, the initial training was provided on an ad hoc basis by the instructors with computer experience who were willing to experiment with the system. Based on this experience, the course managers at SSC GLAKES have developed a 40 hour syllabus for initial instructor training on how to use the technology in the classroom. This syllabus will be used to train incoming instructors in the mechanical technician courses and it is being modified to train electrical technician course instructors. Instructors are sent through the Windows tutorials if they do not have the basic computer skills.

The instructor IETM course covers use, operation and basic concepts of the:

- Instructor station.

- Student station.

- Classroom network capabilities.

- LINK system incorporated into the classrooms.

- Xerox Liveboard large display.

- Video (VCR) support.

- Data base management for the testing system incorporated.

IETM navigation, including launching of animations, browsing and searching, using bookmarks, annotations, and use of the view packages for guiding through the IETM in a preset mode is also taught. Note that little is taught on authoring, per se, in the course. There is no equivalent of the Army IADS. COTS is used for developing graphics and animations and the IETMs are presented via COTS viewers. Members of the instructional staff require training in COTS applications software that is used to author the instructional materials and develop multimedia training aids. Instructor authoring training should be considered to reduce the learning curve and increase productivity.

Currently, the authoring skills are learned by instructors on their own, through more experienced instructors and developers in the school. Most techniques and tools used seem to be a function of the energies of the instructors. They need to be involved in the process of creating the end product for use in the classroom. Instructors are the primary source of innovation and key to the success of the use of the system; including modifications of the Instructor Guides and incorporation of new electronic materials. As part of the lessons learned, weekly instructor training programs are scheduled to share corporate knowledge, float ideas, and demonstrate proven concepts (Fretz, 1995).

Other staff training is critical for successful implementation of the classroom with IETM-based technology. Appropriate training must be provided for course management and support personnel. The need for qualified personnel to perform system administration tasks and, especially, network administration tasks cannot be emphasized enough. As stated by Fretz (1995):

For now, the resident "computer geek" simply learns on the job and from vendors/installers. This corporate knowledge is perishable and puts the school up against a rock when the military member transfers. It is possible to ameliorate this situation with a GS/contracted network administrator, but continual training programs are a must. (pg. 2)

If qualified civilian or contractor personnel are not hired, then formal training programs in microcomputer hardware and software configuration management and certification as a network administrator are essential for military personnel assigned those duties.

4.3   Implications for Embedding Training Content in IETMs

A common description of IETMs, across all branches of the services, included statements that referred to the embedding of training into IETMs. That is, the developers and sponsors of IETMs typically think in terms of including training within the IETM document for access by the user on-demand. While this is a somewhat appealing benefit at first hearing we think there is an important issue to be discussed. The question is, what training should be included with IETMs and when should it be available. A primary question is should the content of IETMs include formal instructional materials embedded into the documents? If so, should instructional managers or instructors be involved in their design along with technician experts? What is the source for the content? What is its relationship to the curriculum management and surveillance requirements of NAVEDTRA 135? Initial efforts to combine training materials with the technical document itself, as opposed to an integrated data base from which all materials can be generated, do not seem to have had any advantages and may have been a detriment to being able to update the training materials independent of the IETM document.

One example of embedded training is the GS IETM. In this case the formal school Instructor Guides (IGs) and Trainee Guides (TGs) were revised with SGML tagging to launch and access parts of the IETMs and placed on the IETM CD-ROM. Several difficulties occurred. First, the guides are now difficult to revise separately from the IETM revision cycle. The GS course IGs and TGs authored using AIM were integrated into the IETM database and the link with AIM was lost. The links between IETM databases and other major Navy systems like AIM need to be analyzed to allow data from diverse sources to be dynamically managed. The schoolhouses need to retain control of the IGs and TGs and the course revision process needs to be independent of the IETM development and revision process.

A second problem was that the student has access to the IG if the CD-ROM was used for distribution. The school therefore reconfigured the student stations to download and store only the pertinent information rather than use the CD-ROM. Third, the requirements for course configuration management set forth by NAVEDTRA 135 were bypassed and the course is unapproved. Given that hindsight is a powerful tool for wisdom, we do not wish to criticize the developers of those IETMs and the school for what seemed reasonable at the time. However, it is now a lesson learned of what additional considerations are needed in thinking about integration of training and technical information.

A more effective solution seems to be the integration of data bases through common definition of technical and training data elements. This common basis for application development

can then be structured and managed to the benefit of all in parallel, but allow asynchronous application development and updating.

4.4   Integration of Training Data with Technical Information

In discussions with members of the logistics, maintenance, publications and training communities, we often encountered a thread of conversation that defined both technical and training information as data elements. Specifically, many voiced the opinion that these data elements can be better defined and integrated to serve the goal of more effective maintenance, operations and training. There were, however, differences in how to accomplish this. While everyone recognized that the technical information could be drawn for use in training, the questions of how to use that information and how to integrate training with IETMs varied with the perspective of the organization the individual represented. Several options are discussed below.

4.1.1   Use of IETMs as Training Media

From a training developers viewpoint, IETMs can be considered as one of the media resources available. Thus, they are treated as any other resource, such as text, video, graphics, devices for laboratory activity. Through media analysis and instructional design activities, the developer identifies how and when the IETMs are to be incorporated into the sequence of other instruction needed to meet learning objectives. However, the training materials, including the IG and TG, would be kept separate from the IETMs. In this case, the IETMs would be launched by the instructor, the IG, or even interactive courseware (ICW) designed to interface with the IETMs to allow activities such as troubleshooting in laboratory exercises.

4.4.2   Use of IETM Data as a Source for Developing Training

Another way to think of IETMs is as a source of data for developing training materials. Several of the organizations surveyed pointed out that the IETM data base of technical information contains the same information needed to produce CBT. In fact, it is typical when developing any instructional material of a technical nature to draw from the job documents, when they are available, for source data. Similarly, it is hoped by IETM end user organizations in the training world that CBT can be developed with automated aids from an IETM database.

While most efforts are either only conceptual or in the planning stages, one Air Force research agency, Armstrong Laboratory, and its contractor, Mei Technology Corporation, have achieved some success along these lines (Spector, Arnold, & Wilson, 1995). The effort makes use of a prototype system, XAIDA (Advanced Instructional Design Advisor), that was developed to automatically generate CBT courseware from information input by a subject matter expert (Walsh & Daly, 1995; Wilson, 1995). In this case, the researchers identified IETM database elements applicable to training, using an IETM for the F-16, and then developed software to parse the information for input to XAIDA. To date nomenclature, location, parts, and task steps for testing and repairs have been parsed with some success and input into XAIDA for lesson generation. According to research reports, the lessons generated are neither complete nor polished, but they can then be used by a subject matter expert to quickly complete the lesson. The savings in time to develop CBT was reported to be on the order of hundreds of labor hours per hour of instruction since a sample lesson was generated in about ten minutes.

4.4.3 Common Data Elements and Integrated Databases

Given the cost of data development both for manuals and training and the commonality of information used in both applications, it seems reasonable to consider the possibility of defining the data elements so that such diverse applications, as well as other logistics applications, could reuse the same data with ease and efficiency. The goals would be to develop data once and to define it in such a way as to facilitate electronic data interchange among applications. There are several movements in progress that make this more feasible now than in previous years. Although, all of the pieces are not in place, it is worth discussing the efforts that are underway that may influence the possibility of achieving a common database.

First, we note that at a top level of DoD the CALS program has as one of its initiatives the development of an integrated weapon system database. The technical information in this database would include common data elements in use across weapon systems and most likely would have a great deal of the information needed for IETMs including equipment characteristics, logistic analysis of tasks to be performed, procedural element of the tasks, and definitions of operator and maintenance personnel. In recognition of such goals as those of CALS and others, the Defense Information Systems Agency (DISA) has been set up as the DoD steward for DoD data standardization. The goal by DoD of data standardization and administration, as stated in DoD Directive 8320.1, is to:

> a. Support DoD operations and decision making with data that meets the need in terms of availability, accuracy, timeliness, and quality.
>
> b. Structure the information systems in ways that encourage horizontal, as well as vertical, sharing of data in the Department of Defense, and with other government agencies, private sector organizations, and allied nations, consistent with national security and privacy requirements. (p.3)

To achieve these goals, specific procedures for data element standardization, DoD 8320.1-M-1, and data administration, DoD 8320.1-M, have been defined by DISA.

Another recent occurrence is even more directly related to providing a basis for definition of training data elements for an integrated database and enhancing capability for electronic data interchange. In June, 1995 the decision was made by the Defense Standardization Improvement Council (DSIC) to convert, by June of 1996, MIL-STD 1379D to an acquisition guide with specifications for training data required. DSIC is the office established by Defense Secretary Perry to oversee the process of standards and specifications conversion. The conversion is part of the Secretary's direction toward overhauling these documents with the view of doing business in accordance with best commercial practices and minimizing government oversight functions.

In response to the Secretary's direction, a Defense Training Standards Working Group (DTSWG) has been established with Naval Air Systems Command PMA 205-4B as both the preparing activity and as the chairperson (Cogan, 1995). The DTSWG, supported by contract efforts, is now working toward definition of training data elements. An IDEF (Integrated Computer-Aided Manufacturing Definition) training data model, in conformance with the DISA

procedures for data element standardization, is scheduled for completion by December of 1995. The converted MIL-STD 1379D is expected to have training data entity and attribute specifications, an IDEF 1X logical model view, a user view, and product/data element applicability cross reference (p. 2). Upon completion of this effort it might be expected that these definitions will be the basis for submittal to DISA.

However, what is missing is a similar effort by the IETM Tri Service Working Group or an organization under their direction. A valuable step, from the standpoint of the training community, toward database integration and electronic data interchange would be taken by that work. Certainly, there are those who would like to draw from the IETM databases to generate CBT (Dorman, 1995; Robinson, 1995) and other instructional material, as demonstrated by the Air Force XAIDA project described above. It is likely that applications could make use of the power of an integrated relational database as well as the SGML tagged IETM database. It should be noted that although the DTDs define data elements and entities for a given IETM application it was stated by several of those interviewed in this survey that although two different IETM applications comply with the IETM specifications they can not talk to each other. The SGML databases are not compatible with each other and can not be queried by another application for extraction of data with the same format, technique, and software.

One effort that may be immediately addressing the access of IETM, as well as other logistic data, is the AIM I and II software developments going on under the auspices of the Software Support Office (SSO) at the Naval Air Warfare Center/Training Systems Division (NAWC/TSD). Several of our conversations with personnel outside of that organization indicated that it is intended that AIM access IETM data in SGML form for development of instructional material, derive IETM element and entity identifiers for inclusion in the Related Instructor Activity column of the Instructor Guide and map the AIM DTDs to the IETM DTDs. We have been unable to confirm this directly with NAWC/TSD to date.

4.5   Impact on Education

In our survey, we found that educational organizations, including institutions of higher education, were very active in producing and using hypertext/hypermedia documents. However, in most cases these were focused on simply the linking of information and access through either free or guided navigation. That is, there were seldom smart features used to solve problems. There are several interesting exceptions to this. For example, there are several SGML-based applications that have been developed to support scholarly research in the arts and humanities. The SGML structures are used to define and relate content in ways that scholars ask questions. However, the question needs to be asked whether the IETM technology has broad application in the educational sectors. We believe that the answer is yes, especially when intelligence is put into the document.

As defined by Siegel (1993) of Indiana University, the virtual textbook is an example of how intelligence can be applied. The virtual textbook is conceptualized as a hypermedia application (not SGML based) that combines local and distributed course content in a problem-centered delivery environment. The model of instruction for the virtual textbook emphasizes teaching about problems to be solved, skills to solve problems and providing tools for accessing information. This is opposed to a focus on teaching the information itself.

The following paraphrases Siegel's description of old and new models of instruction. First, the teacher will be a facilitator, a resource provider, and will not be expected to know all of the information and deliver it. This contrasts with the current model of teachers as disseminators of information with full control of the classroom learning process. Second, the student will be an active and interactive researcher, problem solver, and learning strategist. The student will learn through effective use of information and problem solving techniques. This contrasts with the current models that treat the student as a receiver of information and test taker who works alone to memorize and learn. Third, the content will be treated as interdisciplinary rather than sets of information that are separated and organized by "disciplines" or artificial units The point here is that there is too much information to memorize. The goal is to teach students how to access information, determine relationships, use it to solve problems, and develop multiple perspectives on the information.

IETM technologies can be used to support such goals in education. As discussed earlier in our review of SGML applications in higher education, we see similar uses of SGML and IETM technologies for case-based education and training in the military, There are many military instructional situations where it is more appropriate for the events of learning to be adult, learner-centered rather than instructor-centered.

Section Five

Differences Between Job Performance Support Documentation and Training

5.0 Differences Between Job Performance Support Documentation and Training

A major issue that has arisen in the past two years, and is gaining strength in its significance, is how much should IETMs encompass training? That is, should IETMs include part or all of the training that will be needed throughout the career of a end user. There are many implications that have not been addressed yet regarding this central issue. For example, if instruction is included in IETMs who will:

- Define it as a requirement and continue to assess that requirement.

- Design it for effectiveness, taking into account differences in target population characteristics.

- Design it, taking into account media selection principles.

- Design it, taking into account instructional strategies for different types of learning and learners.

- Manage the configuration from a basis of both instructional and job performance effectiveness.

- Manage the continuing support required for the combinations of classroom, fleet and just-in-time training.

There are several proponents for including training within IETMs on the grounds that the technical information database can be the same and that the same technology, such as SGML, can benefit both. For example, as stated by Alligood (1994) An IETM, or more appropriately an Interactive Electronic Training, Operations, and Maintenance Support System (IETOMSS)is a database of information that includes and/or provides linkage to all technical information to support training, operations and maintenance for a set of systems or equipment.(p. 3)

In this section, we will describe the pros and cons of including training within IETMs. We will also argue that while it will be effective and efficient to have one technical information database for both applications and that SGML and other technologies underlying the IETMs can benefit the training world, there are two different goals to be reached and it is not proper to define the same structure or content for an IETM as one would for a training document. We will further discuss the role of structures and navigation for job performance support documents like IETMs versus similar documents meant to instruct and allow acquisition of learning. Specifically, these issues will be illustrated by discussions of some instructional design issues for hypertext and two of the media, animation and video, that are commonly called upon for inclusion in IETMs.

5.1 Hypertext and Learning

Our thesis concerning hypertext for learning is that it should be structured for that purpose and that to do so in an IETM could thwart the goal of developing the IETM as an effective job

performance support aid within the context of an integrated maintenance system. However, before developing that argument we should point out that not all documentation should necessarily even be in hypertext format. In fact, it may be better to have some things in paper format rather than electronic. For example, if we consider existing classroom instruction it may not be worthwhile to convert Student Guides (SGs) at all. In other cases, parts of the SGs may benefit from the hypertext treatment. The instructional analysis and design process should determine if there are links to information worth including or launches to IETMs or other external electronic media that need to be incorporated. In such cases a complete hypertext/hypermedia format may be appropriate.

The criteria should be based upon relative effectiveness between media forms. It is a fact that the paper, linear form and the electronic, hypertext/hypermedia form are two different media. This is not simply a matter of replacing paper in the classroom or providing training that can be more in line with the goals of IETM implementations. The paper versions of SGs, or portions of them, may have some advantages over hypertext versions that will have to be evaluated on a case-by-case basis. Shneiderman, Kreitzberg, and Berk (1991), who have been concerned with computer-human interfaces for the last several years, have pointed out that the printed, paper version of a text may be more appropriate at times than hypertext (Shneiderman, Kreitzberg, & Berk, 1991). To paraphrase their logic the printed page:

- May have better resolution which could be needed for color graphic s or some other visual.

- Is portable and can be taken to places that the hypertext/hypermed ia might not (such as out of the classroom, off the base, and off the ship).

- Is convenient to make notes on and highlight portions for study.

Shneiderman, et al suggest that there are "Golden Rules of Hypertext" to be applied as a test for hypertext treatment. These rules assume there is a large body of information organized into numerous fragments, the fragments relate to each other, and the reader needs only a small fraction at any time.

However, from the standpoint of training effectiveness, the more important issue is the need to structure text for a learning experience as opposed to a job aid. To do so requires an analysis of the student and the content. Although it is certainly possible to treat a paper text as nonlinear and jump around from page to page, it is probably a better form than hypertext to ensure that dependent learning sequences are followed, especially by learners who may not be good at learner control.

Specifically, the hypertext/hypermedia treatment allows much more learner control with the possibility of getting "lost in hyperspace." There is research to indicate that hypermedia readers, especially novice readers, can have problems in accessing and sequencing information in a large database (Gay & Mazur, 1991). There are a variety of techniques to assist the user that can minimize reading problems. However, since it can happen, it raises a point about which Navy students may be suited to hypertext/hypermedia materials and which may not. One recent attempt to identify and describe the effective dimensions of interactive learning systems, including interactive multimedia of the sort that could be developed for Navy classrooms, concluded that learner control is a very complex issue for which more and better research is needed (Reeves, 1992;

Reeves & Harmen, 1993). That certainly applies to the varieties of students and learning tasks in Navy classrooms.

One recent study of learning with hypertext found that there is a difference in learning between students with low prior knowledge and high prior knowledge. Hillinger and Leu (1994), using content based on a turboprop engine (the content was intended to be functionally similar to the LM2500 marine turbine engine), compared the two groups of students across two levels of hypertext control. In one instance, the user was able to control the navigation freely without constraints. In the other condition, the user was provided system control via a guide window that listed specific instructional objectives, and at the users selection of a given objective, provided instructions on how to navigate through a hypermedia landscape to meet that objective.

Using a 2 X 2 analysis of variance it was found that there was a significant interaction of scores between the level of prior knowledge and the level of control. That is, the low prior knowledge subjects learned more under system control but high prior knowledge subjects learned more under user control. The researchers concluded that this is consistent with findings of other studies. Inexperienced learners have the most to gain from system guidance. We suspect that most learners assigned to a NAVEDTRACOM course could be called low prior knowledge learners and that the need for guided learning applies.

Another study looked at the effect of some different but related learner characteristics (Jacobsen & Spiro, 1995). Specifically, they looked at the influence of learning in a hypertext environment from differences in learner epistemic cognition. Epistemic cognition is the learners beliefs about learning. They include what the learner believes are good and bad ways of how to learn, his/her general capability to learn, the nature of the content to be learned and the learners ability to control learning. A learners epistemic beliefs were suggested to be associated with whether or not learners can integrate new knowledge with prior knowledge as well as other aspects of learning.

Epistemic beliefs and preferences (EBP) was measured by an instrument with 19 pairs of statements related to students beliefs about learning. Each pair had a positive and a negative-worded statement. Learners were asked to agree or disagree with each statement on a 7-point Likert scale. The content to be learned was the impact of 20th century on society and culture. The researchers considered this domain to be complex and ill-structured. The topic had many concepts that could be applied to dynamically changing real world events. Three forms of the hypertext learning environment were used in the study: (1) a minimal hypertext drill similar to traditional computer-based-drill programs to identify a single them about the topic, (2) minimal hypertext drill as in the first control condition but with the requirement to identify multiple themes, and (3) thematic criss-crossing hypertext. The latter was the experimental condition and consisted of noting multiple themes through criss-crossing different cases that had been previously linked based on conditions of technology and societal combinations.

Measures were taken from transfer tasks including essay writing on the topic. Learners were categorized as simple EBP and complex EBP. A simple EBP learner preferred simple content and memorization of pre-specified content. A complex EBP learner welcomed working with complex knowledge content and valued his /her active participation in the learning process. It was found that complex EBP learners who received thematic criss-crossing hypertext, rather than either

of the two control drill conditions, scored higher on the transfer task than did simple EBP learners. The researchers interpreted this to be related to simple EBP learners having had difficulty with the nonlinear and multidimensional aspects of the hypertext. We think that these findings also suggest additional concerns for ensuring that hypertext is designed to support the learner, not job performance, in Navy training. While the job-aiding IETM is designed for that performance support, learning materials should be designed for learning.

There are many variables and treatments to be considered in hypertext/hypermedia for learning. We have only touched on a few considerations here to suggest that there is an important difference in the design of electronic documents for achieving goals of job performance support versus learning. Gall (1994) of the U.S. Air /Force Academy's Center for Educational Excellence has proposed one framework for considering the pedagogical considerations in design of hypertext learning systems. As shown in Figure 2, Galls framework relates learner attributes, the learning task, the educational setting and the hypertext learning system. We argue that each of these should be considered independently from IETM developments at the present time, and under the purview of training specialists, until more experience with the integration of IETMs in Navy training is available.
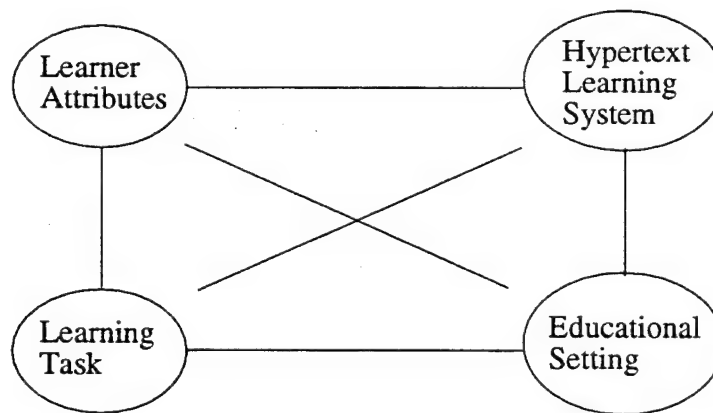

Figure 2. Relationships among hypertext learning environment components.

5.2   Animation and Learning

One nontext media form that seems to be talked about a great deal for IETMs is the use of animation. Animation is certainly an advantageous feature possible in an electronic document that is not available in paper form. There are also probably many applications for it that are meaningful for supporting job performance in the maintenance of complex military systems. For example, animation could be used to show a part on a piece of equipment that is not readily visible or identifiable or easily discriminated from another part by rotating the equipment and zooming in to show its location and contrast it to other locations.

Animations to be used in learning environments have additional instructional considerations. A recent comprehensive review of literature (Wetzel, Radtke, & Stern, 1993) regarding instructional animations has surfaced some of the main aspects to be considered. They concluded that the effectiveness of instructional animations has been shown more with younger learners (e.g. grade and high school students) than with adults. Of 16 studies with adults that compared the effectiveness of animations against non-animation techniques, such as static graphics, only three produced positive results. Part of the reason for this, however, may be related to how the animation was used. When animation is used by itself to present content it was seen to be relatively less effective based on the studies reviewed. When it is used with practice, probably with direct manipulation interactions so that learners can see changes occur in direct and continuous response to their actions, learning can be effective.

According to a history of direct manipulation written by Hutchins, Hollan and Norman (1986) there are three properties of direct manipulation:

1. Continuous visual representation of the object of interest in relationship to user actions.

2. Physical actions or labeled button presses which can be taken by the user instead of complex syntax commands.

3. Rapid, incremental, reversible operations whose impact on the object of interest is immediately visible.

An example of this approach familiar to Navy training personnel (and developed initially by Hollan and colleagues) is the Steamer Intelligent Tutor developed at NPRDC in the mid to late 1980s. As stated by Hutchins, et al (1986) we see promise in the notion of direct manipulation, but as yet no explanation for it (p.92). These authors go on to say that examples of this technique seem to feel natural to users because they also provide a feeling of directness. They then go on to develop a psychological framework which defines two aspects of directness: distance and engagement. Distance refers to the space perceived by a user between his/her thoughts and the physical requirements/state of the computer. Engagement refers to the perception by the user that he/she is directly manipulating the objects of interest by the actions being taken.

This theoretical notion is consistent with conclusions reached about instructional animations by Rieber and Kini (1991). They concluded that the primary advantage of animations, over static graphics, is the visual representation of change or movement over time. They also suggest that the animation enhances the learners ability to perceive apparent motion and thereby lessens the cognitive load in learning, freeing up the learners resources to attend to other aspects of the learning task. Rieber (1990) made three design recommendations for the use of instructional animation:

1. Animation should be incorporated only when its attributes are relevant to the learning task. These attributes are visualization, cognitive meaning, and motion.

2. Since novices may not know how to attend to relevant cues provided in the animation, learning should be packaged to include text, static graphics or other forms along with the animation.

3. The power of animation for computer-based instruction may be in interactive graphic applications.

We see these conclusions as consistent with the concept of why direct manipulation interfaces are of value, but we extend the requirements for instruction to include multiple forms of support to the learner through text explanations, still graphics, and instructors themselves. However, not all students are successful in all situations learning this way and the exact composition of animations, text, narration, and other visuals is still under study. Research is in progress to better define when to use this form of computer user interface. For example, some of the research to date indicates that:

- When a verbal description of a simple operation (using a bicycle tire pump) was given either before or during the presentation of an animation the during group outperformed the before group on a related problem-solving test (Mayer & Anderson, 1991).

- When a verbal description of the bicycle tire pump operation was presented with no animation, a narration without the animation, and a verbal description during the animation, the during group again outperformed the others (Mayer & Anderson, 1991).

The latter results were interpreted by the researchers to support a theory that there are two kinds of memory coding related to these two different forms of information. One was termed representational connections and occurs between either verbal stimuli and verbal representations or between visual stimuli and visual representations. The other is called referential connections and occurs between visual and verbal representations. The researchers concluded that the results support a view that students use both words and pictures, such as animations, to build an effective mental representation of how a system works through referential connections. Verbal and visual presentations should be presented together in order for students to make referential connections and for more powerful learning to occur. Presenting verbal and visual explanations without connecting them is not as helpful as connecting them.

We suggest that this may also relate to why a direct manipulation is so effective. The instructor normally explains what is happening when this technique is used for a demonstration. When a student uses it, however, he/she must generate the explanation themselves for it to be effective unless we provide explanations simultaneously to the student and ensure the connection is made instead of letting it be discovered. Thus, Navy training could be served well to provide animated simulations, in a direct manipulation mode, for both demonstration with instructor explanations, and as stand-alone devices for students as long as concurrent explanation can be provided. This may be very different from the IETMs animations used for job support.

5.3   Motion Video and Learning

Video sequences that demonstrate procedures to be performed, show the characteristics of equipment in motion, or in some other way depict movements that the IETM user needs to discriminate have also frequently been discussed by IETM developers as desirable aids to performance support. There also seems to be an implication that these videos are instructional and could carry instructional value. We again caution against the assumption that the motion video used as a job aid is the same as one used for instruction. Just as described for animation above, the

instructional characteristics of effective motion video are dependent on student attributes such as prior knowledge and level of experience; breadth, depth and complexity and of the content; the instructional setting including availability of an instructor or other experienced person who can coach and explain; and context with other media including text or media that supplement views of the video.

Wetzel, et al. (1993) recently reviewed studies of video and film motion used for procedural learning. As described by those authors, motion is widely thought to be effective as a visualization technique in instruction. Benefits attributed to video motion in the research literature include its capability to show the motion or other visual information itself, visually present discriminations needed, gain attention, depict continuity in sequential-spatial relations, or represent information that is difficult to fully describe verbally. One interesting conclusion reached by these reviewers was that the studies clearly showed a powerful benefit to result from the addition of hands-on practice... (p.63). This implies to us the need to design an instructional setting, perhaps in a laboratory situation, where such practice can be available. In addition, the motion sequences found to be effective in comparison to other techniques, such as static graphics or text, often only depicted selected aspects chosen for pedagogical reasons. The designers, for example, specifically used motion video or film to enhance instructional effectiveness by showing features for critical discriminations.

There are many considerations in making a video, whether for job performance support or instruction and this is not the place to cover them in detail. We do, however, hope that the point is made that an IETM developed for effective job performance support cannot be expected to be the same vehicle for effective instruction even if it incorporates good videos, animations and other media.

Section Six

Conclusions

6.0 Conclusions

In summary, we offer the following conclusions.

6.1 Preparing and Supporting the Training Setting for IETMs

In Section 4 we discussed the lessons learned and issues that have arisen when IETMs are introduced into the classrooms and laboratories. A major impact is that there may be refurbishment needs for the physical facilities, such as air conditioning and power, and, of course, the acquisition and continuing support of the IETM computers. These are important considerations that require planning and budgeting well in advance of the need to conduct IETM-based training. Organizations such as the NAVSEA and CNET are taking leadership roles in their areas of responsibility in the Navy to provide an adequate basis for implementation and support in the future. However, the procedures and techniques are still new and can be expected to be fine tuned later. Certainly, an important constraint is time. The normal planning time needed for budgeting in training may be a problem to integrate the number of IETMs that will be implemented in the near future.

6.2 Changing Nature of IETM Electronic Classrooms

In Section 4 we pointed out that the introduction of computers into the classrooms and laboratories to support instruction using IETMs parallels the movement to implement electronic classrooms. To some extent, the current mental model of the classroom as an instructor-led, on-the-podium, group learning setting is now being simply transferred over to the IETM based electronic classrooms. We do not argue against this as a first step, but suggest that changes in student learning and the instructor roles may be worth considering in the next few years. It is suggested that not only can the instructors role change, but so can the students. The IETM- based electronic classroom can be structured for students to take more responsibility for themselves and with each other.

In addition, it can be expected that the definition of the classroom will continue to change as its functionality is enhanced by the new technology available. The virtual classroom may be one of those ways it changes. The networked virtual classroom, whether for physically co-located groups or physically separated individuals, offers the promise of distributing the instruction to more people with less instructor resources.

6.3 IETMs in On-Demand and Just-In-Time Training

As also discussed in Section 4, the IETM-based training is being projected to result in fewer courses and less training time. Several military agencies responsible for the implementation of IETMs and training are studying the option to move more training out of the classroom by supporting performance in the field with smart IETMs and computer-based training (CBT) that can be accessed as needed. Although no organization we surveyed was considering total elimination of classrooms and associated laboratories, especially for initial training of apprentices, there was a definite inclination to reduce the formal, centralized school time. This initiative revolves around the concept of just-in-time training with a performance support system. Just-in-time training seems to be a focus especially for the military and industry areas of aircraft maintenance.

6.4   IETMs as Expert Job Aids

As described in Section 4, several of the organizations interviewed expressed strong preference for moving the capability to support the technician through more use of IETMs and less use of training. The more intelligence that can be put into an IETM, the better the operators and maintainers of equipment can be supported to fix what breaks. This is certainly a redefinition of jobs and training requirements as a result of IETM technology. However, we note that not all IETMs will have such a capability. The cost of developing class 4 and 5 IETMs versus class 3 IETMs may be a stumbling block. The economics of IETMs is beyond the scope of this report, but we hesitate to suggest that smart documents can be built in the near future to impact a wide number of jobs. Many IETMs for mature systems will lack the smart performance support features and will not be integrated into a total maintenance system.

6.5   Implications for the Organizations

The integration of IETM technology into training and education requires a look at the coordination roles and functions of organizations. There appears to be evidence that training and documentation organizations will need to change at several levels. Typically in the past, large organizations inside and outside the military have had one unit responsible for documentation and another one responsible for developing and operating training. Because of the impact on both areas, it will be necessary for even greater coordination between the agencies and, most likely, an integration of the agencies at least for the purpose of developing and managing IETMs. This will be especially true if the path of an integrated data base is taken.

6.6   IETM Data as a Source for Developing Training

As discussed in Section 4, one way to think of IETMs is as a source of data for developing training materials. Several of the organizations surveyed pointed out that the IETM data base of technical information contains the same information needed to produce CBT. In fact, it is typical when developing any instructional material of a technical nature to draw from the job documents, when they are available, for source data. Similarly, IETM end user organizations in the training world hope that CBT can be developed with automated aids from an IETM database. Efforts, like that by the Air Force Armstrong Laboratory with XAIDA, to automatically generate CBT courseware from information input from IETM database elements may save a great deal of time and money and should be continued. The Navy AIM I and II developments may also be pursuing similar objectives.

6.7   Common Data Elements and Integrated Databases

Given the cost of data development for both manuals and training, and the commonality of information used in both applications, it seems reasonable to consider the possibility of defining the data elements so that such diverse applications, as well as other logistics applications, could reuse the same data with ease and efficiency. The goals would be to develop data once and to define it in such a way as to facilitate electronic data interchange among applications. There are several movements in progress that make this more feasible now than in previous years. However, not all of the pieces are in place. In Section 4 we suggest that it is well worth studying, perhaps through a joint service, multi-disciplinary committee, the possibility of achieving a common database and

leveraging the efforts underway with MIL-STD-1379D to influence the possible accomplishment of the goal.

6.8   IETM Technology in Education

In education the goal is often to teach students how to access information, determine relationships, use information to solve problems, and develop multiple perspectives on the information. IETM technologies can be used to support such goals in education. As we discussed in Section 3.3, we see similar use of SGML and IETM technologies for case-based education and training in the military. There are many military instructional situations where it is more appropriate for the events of learning to be adult, learner-centered rather than instructor- centered.

6.9   Embedding Training Within IETMs

In Section 5 we expressed concerns about including training in IETMs based only on the same technical information required for job performance support. We attempted to make a case to show that there is a gap in the understanding of some people in the IETM development world of how training materials are designed to meet goals for learning. It is our contention that while IETMs and training need to be integrated it must be done so with full partnership of those in the training community who can provide expertise in learning with the technology of hypertext/ hypermedia, and new digital media such as animations and video.

We have also raised questions about roles and authority of organizations if instruction is included embedded in IETMs. For example, who will:

- Define it as a requirement and continue to assess that requirement.

- Design it for effectiveness, taking into account differences in target population characteristics.

- Design it, taking into account media selection principles.

- Design it, taking into account instructional strategies for different types of learning and learners.

- Manage the configuration from a basis of both instructional and job performance effectiveness.

- Manage the continuing support required for the combinations of classroom, fleet and just-in-time training.

It is apparent that these are issues that have not yet been addressed fully at top level training management levels. If training is to move more from the centralized classroom to the field via IETM media, then we recommend a more active role on the part of organizations such as the Naval Education and Training Command, Air Force Air Education and Training Command, and Army Training and Doctrine Command.

6.10   Beyond IETMs and SGML

The technology underlying IETMs-- from computers to communications to displays to databases--has changed dramatically over the ten years or so that the military has been working at electronic technical manuals developments. There would have been no way to predict the directions of that technology except to expect rapid advancement. The next five to ten years will continue to bring evolutions in these and other related technology areas. That we are in motion and not done yet is perhaps self evident, but worth stating anyhow. While we must proceed ahead to achieve gains in effectiveness of job performance and military readiness through IETMs, integrated properly with training and education, we should do so with a wary eye toward determining the best way to do so across time.

We can only speculate what some of these technology evolutions will be by talking about what is happening today. Certainly we can expect in the next few years to see greater use of hypermedia including media elements such as animations and video. Better hardware and software techniques for handling and generating media elements will provide more cost effective accessibility with greater capabilities even within the next year. As pointed out by Hanlon (1995b), IETM lessons learned recently have suggested the need for incorporating HyTime as a software neutral way to capture IETM intelligence and Metafiles for Interactive Documents (MID) to solve problems of IETM presentation portability. We can expect to see increased bandwidths for distribution of large amounts of IETM type documents as the infrastructure for the information superhighway, on-demand television programming, and related applications becomes real. We can expect to see more development of integrated databases and functionality as market-driven open standards such as Object Linking and Embedding (OLE), Open Database Connectivity (ODBC), and Standard Generalized Markup Language (SGML) are applied and grow. SGML is already being extended to enhance its applicability to such events as the World Wide Web and multimedia documents. There are also several market driven directions that display technology is headed for including lighter, flatter, and higher resolutions. Finally, even now there are considerations in front of the DoD CALS committee that could change the nature of IETMs in the future. We can at the least see better portability, increased functionality, and more integration with other applications. The changes to IETM classification definitions are not done. If IETMs as we know them in their state today can be expected to change so too can the impact on both training and education.

Section Seven

Standards and Specifications

7.0 Standards and Specifications

American National Standards Institute. *Information Processing--Text and Office Systems--Standard Generalized Markup Language (SGML)*. (ISO/IEC 8879), 1992.

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Section Eight

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Section Nine

Distribution List

9.0 Distribution List

Chief of Naval Operations (N16), (N869), (N71)
Commander, Naval Sea Systems Command
Office of Naval Research (Code 34), (Code 342)
Chief of Naval Education and Training (Code 00), (Code 04) (2), (Code N5), (Code L01) (12), (Code 03EE1) (2), (Code N7) (2)
Commanding Officer, Fleet Anti-Submarine Warfare Training Center, Atlantic
Commanding Officer, Submarine Training Facility, San Diego
Commanding Officer, Fleet Combat Training Center, Pacific
Commanding Officer, Fleet Training Center (Code 00), San Diego
Commaning Officer, AEGIS Training Center, Dahlgren, VA
Chief of Naval Personnel (PERS-00H)
Commanding General, Marine Corps Combat Development Command (MCCDC), Quantico (Code C46), (C46MS)
Commander, Naval Training Center, Great Lakes, IL
Commanding Officer, Fleet Training Center, Naval Station, San Diego (Code 021.2)
SERVSCOLCOM, San Diego
SERVSCOLCOM, Great Lakes
COMTRALANT (Code 01A)
COMTRAPAC (Code N-31)
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